The Dock and Harbour Authority

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Editorial

A Record Year for Shipping and Passengers at Southampton Docks.

The year 1936 proved a most successful one for the shipping trade at Southampton Docks.

Two new records were achieved. The quantity of shipping entering the docks increased, and so did the number of passengers.

Inwards, shipping advanced to 18,539,590 gross tons—an increase of 3 per cent. over the 1935 figure (which was in itself a record one), and the number of passengers embarking and disembarking rose to 560,000, an increase of 4 per cent. over the 1935 total and nearly 16,000 more than the previous record established in 1930.

Freight traffic through the docks also increased. A total tonnage—import and export—of 1,130,000 tons was dealt with, and this exceeded the previous year's aggregate by nearly 8 per cent. There were specially notable increases in importations of fruit from South Africa, and timber.

The South African citrus fruit season came to an end in December. For Southampton it was a record one. Approximately 1,900,000 packages of oranges, grape-fruit, lemons, etc., were discharged at the docks. Incidentally, this quantity accounted for over 70 per cent. of the citrus traffic shipped from the Union to this country during 1936.

The close of this season coincides with the opening of the South African deciduous season, and substantial supplies of peaches, apricots, plums, etc., are now being regularly discharged from the Union-Castle Line's vessels for distribution to all parts of the country. This traffic increases enormously as the season advances, and its magnitude may be gauged from the fact that during the 1936 season 4,317,000 packages were received at the docks.

The quayside shed for banana working at Berth 25, Empress Dock, has been entirely re-modelled, and it was used for the first time on January 14th, when the steamer "Chagres" discharged a large shipment from the West Indies. To facilitate the expeditious handling of the fruit and to supplement the quayside discharging equipment, a number of special features have been incorporated in the design of the shed, which has an overall length of 517 feet and a width of 147 feet.

The banana trade at Southampton Docks has grown tremendously since the first shipments from the West Indies and Central America were received in 1931, and the traffic now amounts to 2½ million bunches annually.

Free Port Zone for New York.

The projected free port zone in New York Harbour was to be opened on February 1st. There has been considerable controversy about how it should be organised, for the municipality does not like the responsibility which will rest upon it, according to the plans of the Federal Free Port Commission. These envisage a Public Utility Corporation on which the municipality will be represented, instead of the laissez-faire system of a private company. New York business circles also insist that the functions of the zone should not be confined to warehousing, breaking of bulk and packing, but that manufacture should be allowed too. This question is not yet decided, but the municipality is anxious to avoid expense, and does not want to have to provide much space. At present it is proposed to confine the area to the four quays themselves, which should provide sufficient warehouse room in the first instance. The enclosure of the adjacent area and the provision of a large seven-storey warehouse, which figured in the original project, can be undertaken later when the increase of traffic justifies this measure. This will save the municipality $300,000 by reducing the original expenditure to $500,000, but it seems hardly calculated to attract traffic to the port. A company has been floated in Jersey City to run a free-port area there. The site is better in many ways, for it is adjacent to the railway goods depots which serve the hinterland. The company, too, has a capital of $15,000,000, which would allow the site to be properly equipped, but it is unlikely that the Federal Free Port Commission will allow another free-port area to be established in New York.

Port returns for the summer half-year (April-September), which always has a seasonal maximum, show an important increase of tonnage entered and cleared, compared with the summer of 1935. The figures were 14,034,000 n.r.t. entered and 14,425,000 cleared instead of 13,464,000 and 13,901,000. German tonnage showed the greatest percentage increase, but the total was a long way below the United States and British figures.

Traffic at the Port of Hull in 1936.

For the Port of Hull, 1936 was on the whole a successful year. The shipping of all kinds entering the docks and paying dues amounted to 6,956,948 net tons, as compared with 6,998,929 tons in 1935. The decline of 41,981 tons is not regarded as serious, since the aggregate is one of the four or five highest in the history of the port. It is more than accounted for by the falling off in the exports of coal with places abroad, which at 674,283 tons was 115,143 tons behind 1935. Altogether, however, over three million tons of coal arrived at Hull by rail and river, and of this upwards of two million tons was shipped as cargo and bunkers by the appliances at the docks. The prohibition of commercial relations with Italy and the interruption caused by the political chaos in Spain, had an adverse affect upon Hull's shipping trade in addition to which the near Continental "trades" underwent some contraction owing to the paucity of cargo. On the other hand, imports of timber and grain reached high figures.

The arrivals of sawn wood amounted to 1,024,572 loads, compared with 776,136 loads in 1935, and of pit props and hewn timber 598,552 loads, compared with 279,738 loads—together, 1,623,124 loads, the highest total to be recorded in the history of the port, an increase of, in round figures, 550,000 loads, or more than 50 per cent. Imports of wheat, barley, oats and maize were 1,361,125 tons, against 1,245,722 tons, and of oilseeds, nuts and kernels 654,515 tons, against 739,053 tons. There were good increases in the quantities of provisions, butter, eggs and fruit imported, but sheep's wool, principally from Australia, at 1,681,885 centals, was 73,000 centals down on the year, but still considerably above the average of recent years. Hull has become a large port for the reception of petroleum and as a distributing centre for the North of England, and last year's quantity was 141.6 million gallons, or nine gallons less than in 1935, yet a good advance on 1934.

The Maintenance of Waterways to Harbours and Docks*

By RAYMOND CARPMAEL, O.B.E., M.Inst.C.E.

Introduction

OF the many problems with which the civil engineer has to deal, it is doubtful whether any give him greater concern than those directly connected with tidal waters. No other description of constructional work, although calling for the most skilled knowledge and for the fullest study of local conditions, can cause an equal measure of uncertainty and anxiety as that connected with works mainly affected by ever-changing tidal conditions. This could be amplified by indicating that the majority of the main engineering problems in connection with harbours and docks are due in a greater or lesser measure to water-action, of which some instances are:—

(a) Alteration of tidal contours due either to the attrition of lands adjacent to the sea, with resultant destructive effect on structures constructed for the support of railway and other works, or to the accretion of materials carried in suspension by the sea, tending to reduce navigable depths at the entrances to harbours and docks.

(b) Destruction of structures and erosion of land caused by the increased weight and velocity of water passing down rivers in times of flood occasioned by heavy rainfall, or by rapid rises of temperature in districts where rivers have their source in mountainous country which is covered by snow or ice during winter months.

(c) Slips in railway and other embankments, to find a remedy for which the source of the influx or infiltration of water must be traced in the first instance in very nearly all, if not in all, cases.

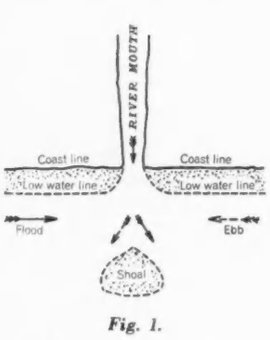
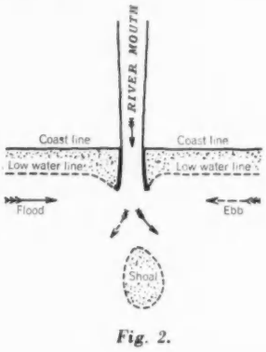


Fig. 1.



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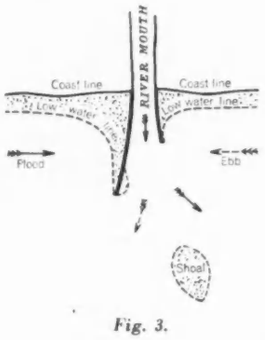

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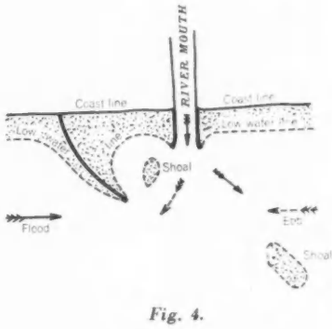


Fig. 4.

The question of the maintenance of waterways to harbours and docks should appropriately be considered under two headings, namely, the causes of the accumulation of silt in navigable waterways and of the destruction of works constructed for their protection, and the methods employed to maintain these waterways.

Causes of Siltation

The causes of the accumulations necessitating artificial works or operations to maintain navigable depths are (a) direct sea-action, causing coastal erosion in one area and deposit of the eroded material in another area, and (b) deposition of silt brought down from inland and carried, particularly during times of heavy rain, by rivers discharging into harbours and entrance-channels to docks.

All over the world unceasing changes are taking place in the seaboard or land-frontages to the sea. In some parts of the coast erosion of cliffs goes on, sometimes accompanied by denudation or stripping of the materials of which sea-beaches are composed, with the result that the sea encroaches on the land and the seaboard travels inwards. The converse of this occurs elsewhere, and by the deposition of materials from the sea, land is formed and the seaboard advances.

It has been conclusively proved that enormous quantities of eroded material are actually borne by the sea from place to place, such travel being known as littoral or shore drift. Deposits of such material from the sea on to the land are made wherever an obstruction, natural or artificial, is placed in the path of its free travel. One of the best examples of the former is Dungeness, projecting some seven miles beyond the general line of the Kentish coast to the north-east of Hastings; its effect in stopping littoral drift is clearly illustrated by the fact that pebbles from Budleigh Salterton, near Exmouth, as well as Cornish pebbles, have been picked up there. Such pebbles are sea-borne, forming part of the great littoral drift which is mainly from west to east along the south coast of England, and of which the motive power is partly that of tidal currents and partly that of waves and currents generated by wind.

Between Hastings and Dungeness very large deposits of material are made, seriously affecting the ancient harbours of Rye and Winchelsea, whilst beyond Dungeness, that is to say, to the north-east, considerable erosion takes place. In 1925 there was advertised in the press the sale by public auction of some 1,000 acres of accreted land at Dungeness, which land had been recovered from the sea by purely natural agencies—the deposit of sea-borne material from the more westerly littorals of Devonshire and Cornwall.

Where such movements occur, any seaward projection from the coast line, whether natural or artificial, forms an intercepting barrier, and when such barriers, for example, breakwaters to provide sheltered waters in entrances to harbours, are constructed, the natural balance of quantities is disturbed. This disturbance may be helpful to places beyond the intercepting barrier where siltation due to accretion would otherwise occur, but it may also be detrimental to places where coastal contours can only be maintained by deposition of materials conveyed by sea action from elsewhere. The harbour engineer cannot evade this inexorable law, and wherever he creates a harbour in tidal waters, thereby causing interference with this littoral drift, he must sooner or later take steps to preserve the necessary depth of water for the safe navigation of the type of ship for which the harbour was designed.

Where natural harbours are situated at the mouths of rivers, a certain balance of quantities is reached between the reactions produced by the river and the tidal currents. The construction of harbour works at or near the confluence of a river and the sea must inevitably disturb this natural balance, and unless this is fully appreciated the subsequent maintenance-costs of such harbours may render their continued existence impracticable.

The Effect of the Construction of Artificial Barriers.

A few typical examples of the effect of interference with littoral forces caused by the construction of artificial barriers are shown in Figs. 1 to 8.* Fig. 1 shows an unregulated river mouth. Fig. 2 shows the same after regulation by two solid piers of equal length. Fig. 3 shows the same after regulation by piers of unequal lengths. Fig. 4 is similar to Fig. 1, but with a projecting breakwater. This method has been adopted at Port Talbot, and also represents the condition of affairs at Swansea where the Gower Peninsula and Mumbles Head form a natural barrier corresponding to the north pier at Port Talbot. A shoal in a position corresponding to the one inside the breakwater in Fig. 4 exists between the Mumbles and the harbour entrance, and is known as the "Green Grounds." Figs. 5 and 6 illustrate different types of construction of (a) a solid and (b) an open breakwater projected from the foreshore. It will be appreciated that the direction of

*Paper read before the Institution of Civil Engineers on December 8th, 1936, and published by kind permission of the Author and of the Institution.

*Based on diagrams on p. 223 of a Paper by Mr. A. E. Carey, "The Sanding-up of Tidal Harbours." Minutes of Proceedings Inst. C.E., vol. clvi (1903-4, Part II), Figs. 12 to 15, and 17 to 20.

Maintenance of Waterways to Docks and Harbours—continued

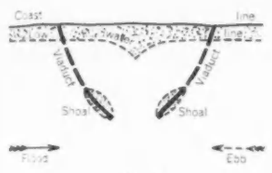
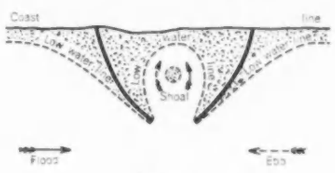


Fig. 5.



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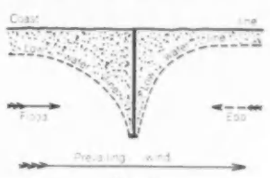


Fig. 7.

Fig. 8.

prevailing winds influences the contour of the low-water line and also the position and shape of the shoals. Fig. 7, which shows the principle of the groyne for foreshore protection, indicates this effect. Fig. 8 shows an open viaduct or pier which, unless designed with openings of sufficient span to suit local circumstances, may offer sufficient obstruction to cause shoaling.

Four actual examples may be cited of the effect of the interception of littoral drift consequent upon the construction of harbour works:—

(1) **Ceará Harbour on the north-east coast of Brazil.**[1]—Here over £400,000 were spent in the construction of a breakwater nearly ½ mile in length, of which the first 250 yards consisted of open viaduct. The work occupied 10 years, but the harbour is now completely overwhelmed by sand with the exception of a small area where a shallow berth is maintained by dredging. Although a short length of open viaduct was provided, free sand travel was checked to such an extent by the solid portion of the breakwater that the whole harbour became choked.

(2) **Madras Harbour.**[2]—Here two solid parallel breakwaters, 1,200 yards long, were projected from the foreshore, curving inwards at their extremities to form an entrance 500 feet wide, the position of which was subsequently moved and reconstructed to face approximately north instead of east. Siltation commenced even during construction of the work and has caused considerable trouble and expense ever since.[3] Unlike Ceará Harbour, that at Madras has been maintained by dredging.

(3) **St. Catherine's, Jersey.**[4]—These works, consisting of a northern breakwater 2,000 feet long and a short southern arm, were commenced in 1848. The harbour is now sanded up and abandoned, with the total loss of the £200,000 spent on it.

large quantities of alluvial matter eroded from the land. The deposition of this matter at or near mouths of rivers forms bars or shoals, accumulations which must be removed. These bars form obstructions to littoral drift, and collect, and are also built up with, material carried in suspension by the sea.

One of the best-known examples of these bars is that at the mouth of the Mersey, from which the enormous quantity of 9 million tons was dredged in 1934 by the Mersey Docks and Harbour Board to preserve open channels for the large liners using the port.

Great Western Railway Dock Problems.

This Paper deals mainly with the problems confronting the Great Western Railway Company in maintaining navigable depths in their Bristol Channel ports of Newport, Cardiff, Penarth, Barry, Briton Ferry, Port Talbot, and Swansea. At Fishguard, however, the circumstances are different, and little, if any, siltation is produced from sources outside the harbour.

Of the six main coal-exporting ports, three—Newport, Cardiff, and Penarth—are situated at the mouths of rivers, namely, the Rivers Usk, Taff, and Ely respectively, which flow into the estuary of the River Severn. These three rivers and the River Wye, which joins the River Severn at Chepstow, are highly charged with alluvial matter in suspension. The Severn itself is similarly heavily charged before reaching Chepstow. In addition to this alluvial matter, the Usk and its tributary the Ebbw at Newport and the Taff and Ely at Cardiff bring down in times of flood very large quantities of coal-silt from the spoil tips of collieries situated in the valleys upstream.

Fig. 9 shows a general map, and diagrams of the principal South Wales ports are given in Figs. 10-15 inclusive. Siltation at these ports from one cause or another may occur rapidly. At

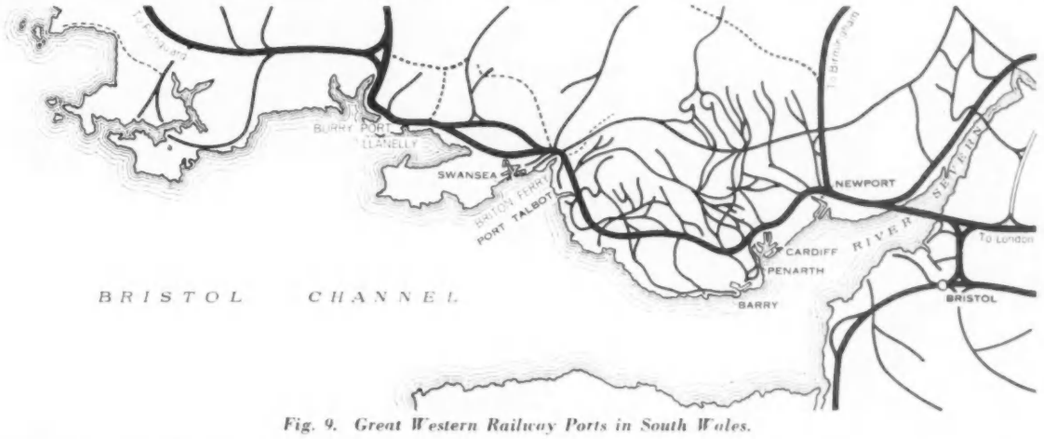


Fig. 9. Great Western Railway Ports in South Wales.

(4) **The ancient Port of Tyre at the eastern end of the Mediterranean Sea.**—The ancient city of Tyre, with the adjoining one of Sidon, was destroyed in 332 B.C. by Alexander the Great. The city, before that date, was partly on the mainland and partly on an island. The former part was first captured and the materials from the demolished buildings used to build a pier or mole, bringing the island city within range of the *ballistae* and other engines of war from which large stones and other missiles were flung on to it. After the capture of the city the pier was extended, linking the island with the mainland. This interference with littoral drift caused the creation of a peninsula of a practically uniform width of ½ mile and 1 mile in length, which was formed by materials carried by the sea and deposited on and around Alexander's narrow mole built for war purposes, a result which certainly was not anticipated by Alexander.

Formation of Bars at River Mouths.

A large proportion of the harbours of Great Britain have been built at the mouths of rivers which—and this is particularly the case with the Bristol Channel ports—bring down

Barry, where no river discharges and where both flood and ebb tides flow very strongly outside the entrance piers, siltation occurs less rapidly. At Port Talbot and Swansea the foreshores and sea-beds consist mainly of sand. The channels at both ports are subjected to siltation from sand, both wind-borne and carried by the sea. This siltation is carried into the docks (a) during operations of "levelling," that is to say, when the entrance lock-gates are opened at or about the time of high-water of spring tides to obtain and impound the greatest possible depth of water in the dock, and (b) when the loss of water due to "locking" can only be compensated by pumping into the docks highly silt-charged water from the channels. Further, into certain of the docks there flow direct streams or feeders which, during their passage through colliery valleys among the Welsh mountains, are themselves often heavily charged with silt, sand, gravel, coal refuse, etc.

Methods Employed to Maintain Waterways

The methods employed to maintain waterways can be considered under two headings:—

(a) Maintenance by artificial works, such as training walls, groynes, etc., to arrest and divert the travel of sand and shingle which would otherwise accumulate and reduce the depths.

(b) Physical removal by dredging or sluicing of such accumulations due either to sea or river action.

[1] A. E. Carey, "Sanding-up of Tidal Harbours." Minutes of Proceedings Inst. C.E., vol. clvi (1903-4, Part II), p. 215.

[2] *Loc. cit.*

[3] Sir Francis Spring, "Coastal Sand-Travel near Madras Harbour." Minutes of Proceedings Inst. C.E., vol. cxciv (1912-13, Part IV), p. 153.

[4] *Loc. cit.*

Maintenance of Waterways to Docks and Harbours—continued

There is an essential difference between training walls and breakwaters. The former are constructed at the mouths of rivers to control and accentuate their scouring effect. The latter are mainly, if not wholly, provided to form an adequate shelter. Both, however, projecting as they do beyond the coast line, arrest coastal drift, and, unless designed with a complete knowledge of circumstances, may occasion troubles far greater than the artificial maintenance of the necessary navigable depths.

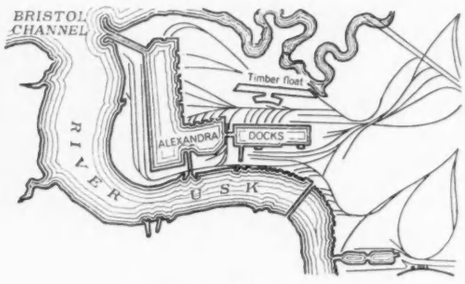


Fig. 10. Newport.

In many harbours, entrance-piers are provided on either side of the approach-channels both for shelter and for navigation. Trouble often arises when such piers are of close timber construction, in that they are incapable of upholding the weight of accumulated coastal drift. If openings are made to permit of the free passage of this drift material, it passes through and accumulates in the entrance-channel to the dock and must be removed by dredging or other means. To avoid such artificial removal, foreshore groynes may be constructed to arrest the drift before it reaches the harbour entrance. An example of this occurred at Penarth, where shingle-travel was arrested by a groyne, constructed at little expense, of old rails and sleepers. This aspect of the matter covers such a wide field that only one other example of protective constructional works will be given, namely, the steps taken to check breaking-through of the River Taff into the main channel abreast of the entrance to the Queen Alexandra Dock, Cardiff.

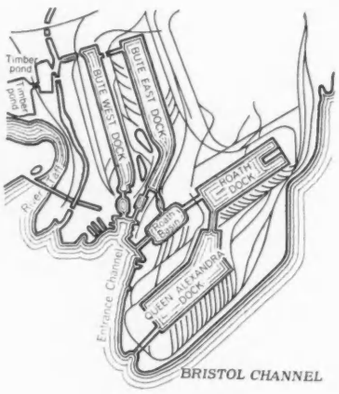


Fig. 11. Cardiff.

The River Taff follows here a sinuous course through tidal mud-flats and, as is generally the case with such rivers, tends to erode its concave banks and to build up by deposit the convex banks. At Cardiff the ultimate effect of this would have been the formation of a new mouth in the navigable channel abreast of the entrance to the Queen Alexandra Dock, resulting in an increase there of siltation. To counteract this,

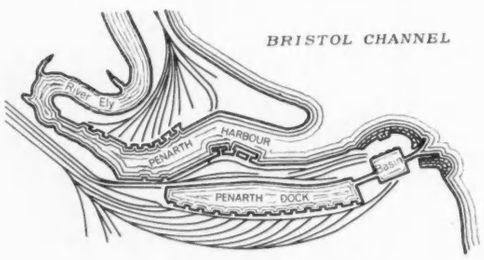


Fig. 12. Penarth.

brushwood groynes were built to arrest erosion, and at the same time the accreted spit in front of the opposite bank was dredged away to lead the river-discharge in a direction parallel to the main entrance-channel. These groynes comprised a line of 10-foot stakes spaced 8 to 10 feet apart and driven into the bed of the river. To these stakes, mattresses consisting of a light wooden framework interlaced with brushwood were fastened by light chains. The groynes varied in length from 60 to 100 feet, and were placed at intervals of 150 to 200 feet along the river bank. After construction they were weighted by depositing on them heavy dredging-cargoes from steam hoppers. These works have proved successful, and their construction has relieved the Great Western Railway Company of the heavy additional dredging costs which the breaking-through of the river into the entrance channel would have involved.

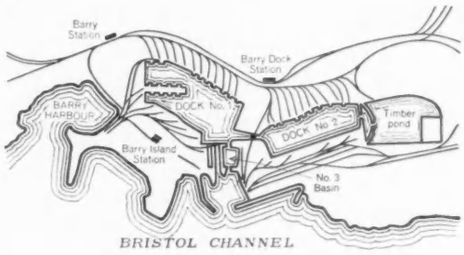


Fig. 13. Barry.

In connection with the best methods of maintaining waterways, the Author cannot do better than quote such an authority as the late Sir William Matthews, K.C.M.G., Past-President, who has put on record on p. 233 of the discussion on Mr. Carey's Paper* that "the whole art of conserving working-

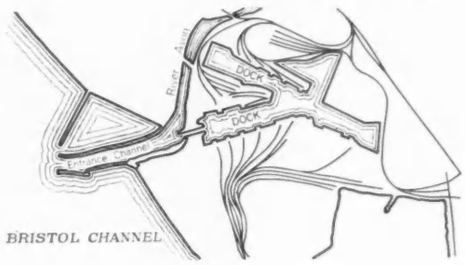


Fig. 14. Port Talbot.

depths in and at the mouths of sand-threatened harbours lay in continual dredging." The Bristol Channel ports form no exception. Under favourable conditions, however, channels can, at least in part, be cleared by sluicing with impounded water released at or about the time of low tides, preferably the spring tides.

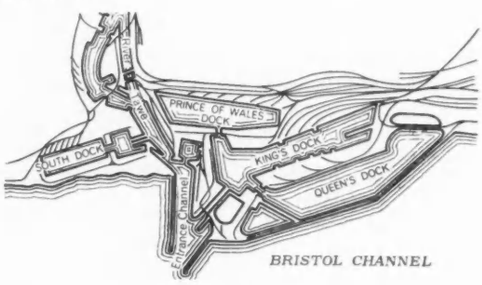


Fig. 15. Swansea.

Short Historical Survey of Dredging Craft

Before describing the methods of removal of silt either by sluicing or dredging in harbours and docks, it will perhaps be of interest to make a short historical survey of such work, from which it will be seen that there is nothing new under the sun.

The progenitor of the bucket dredger was the Persian "chain of pots" used for raising water from wells. This consisted of an endless rope, or pair of ropes, made of palm fibre, to which were attached earthenware pots at uniform intervals. These pots, on passing over an upper terminal wheel 6 feet in diameter, which was revolved by manual labour, discharged their contents into a trough through which the water was led for irrigation or other purposes.

The historian Pliny mentions the introduction of a similar pump into Greece either earlier than or coeval with the foundation of the city of Babylon. It is recorded that the working of these pumps by the daughters of the household was regarded as a very suitable form of punishment for their misdeeds.

(continued on page 111)

* *Loc. cit.*

Notes from the North

Dock Telephone System.

MERSEY DOCKS AND HARBOUR BOARD, in co-operation with the Post Office, has arranged for the provision of direct telephone facilities between the shore and ships in the Liverpool docks.

Hitherto, there has not been any direct telephonic connection possible between a ship in dock and the ordinary service ashore, either in the city or the country, generally. If a person on a vessel in the dock wanted to communicate with any point on land, he or she had to go ashore for the purpose. It has now been planned, by means of flexible cables, plugs and sockets, that telephonic communication may be made between vessels in two docks and the shore, at a rate of 2s. 6d. per day, or part of a day, chargeable to the shipowner to cover local calls originating on the vessels. Trunk calls and te'egrams will involve an additional charge.

The present temporary service will apply only to the Brocklebank Branch Dock, south-east, and the Canada Branch Dock No. 1, south-east side. The registered telephone numbers of these ship-shore telephones are, respectively, Bootle 1534 and Bootle 1524. These two dock positions have been selected for the experiment, because they are possibly the busiest unappropriated berths.

The hirer of the telephones will be responsible for any damage to the instruments, and all third-party risks, during the period of the service.

Manchester's Bid for Exports.

At the annual meeting of the recently instituted General Importers' and Exporters' Section of the Manchester Chamber of Commerce, Mr. H. A. Baerlein, who presided, said a much smaller quantity of goods is exported than is imported through the Port of Manchester. With this in mind, the Port of Manchester Committee proposed that steps should be taken to encourage exporting firms to indicate at frequent intervals the extent to which they would be likely to use the port during the succeeding months. With a definite idea of the size and sort of cargo to be obtained in Manchester, shipowners would be enabled to make arrangements for sending vessels to load in Manchester with a greater sense of security. In 1935, the last year for which complete figures are available, the imports amounted to 1,322,038 tons and the exports to 1,618,613.

Fleetwood Ferry.

Capt. William Fish, manager of the Fleetwood-Knott End ferry undertaking, retired on 31st December. Capt. Fish, who is a native of Fleetwood, was appointed manager 17 years ago. Before that he was employed as a Trinity House pilot for 24 years, and he served his time as apprentice in an old pilot cutter. The ferry's peak year was 1920-21, when more than 1,000,000 passengers were carried. Capt. Fish is proud of the record that there has not been a serious mishap during the period of his managership. The new manager is Mr. Wilfrid George Baillie, of Penwortham.

Dock Weighing Machines.

Mersey Docks and Harbour Board have issued a new scale of rates for the use of public weighing machines. It is provided the weighing charge on all goods and materials in road vehicles, including taring, shall be 2d. per ton, or any portion of a ton net; minimum charge, except for coal, coke, limestone, paving materials, sand, gravel, etc., in road vehicles, 6d.; unladen vehicles, 6d. per vehicle; duplicate tickets for loads weighed in road vehicles, 3d. each; furnishing certificate of total net weight of any number of loads in respect of which weigh tickets have been issued, first 50 loads 1s., every additional 50 loads, or part of 50 loads, 6d.

Certain of the Liverpool commercial associations made representations to the Mersey Docks and Harbour Board directing attention to certain aspects of these new charges, as a result of which the Dock Board has agreed to the institution of a minimum charge of 1s. 6d. per weigh.

Mersey Docks Recovery.

How substantial has been the recovery of trade on Merseyside is revealed by the annual accounts of the Mersey Docks and Harbour Board. Although there has been a gradual decline since 1923 in the number of vessels using the port, the tonnage of vessels paying tonnage rates and harbour dues has been maintained remarkably well, and the total for the year, which ended on 31st July, 1936, falls not far short of the peak year—1927.

The number of vessels which paid dock tonnage rates was 3,987 foreign and 8,502 coastwise, whilst vessels paying harbour rates only were 1,734 and 4,805 respectively, making a total of 19,028, an increase of 1,044 on the previous year. The tonnage of vessels paying dock tonnage and harbour rates made a grand total of 21,023,000, an increase of 500,000 tons on the previous year.

Rates in respect of dock tonnage, harbour services, graving docks and dock rent on vessels, amounted to £1,511,000, whilst the rates and dues received on goods, foreign and coastwise, were £1,018,000, as compared with £957,421 in the previous year. The weight of goods discharged and/or loaded in the Board's docks was approximately 14,500,000 tons, as compared with 13,000,000 tons the previous year.

Income by way of rates and dues amounted to £2,273,000; rents of property, £281,800; dock traffic department, Mersey Cattle Wharf, floating cranes, coaling appliances at Liverpool and Birkenhead, £224,800; landing stages and riverside railway station, £16,900; and services of vessels engaged on conservancy work and miscellaneous receipts, £42,100, making a total of £2,839,000. Not far short of 50 per cent. of this gross revenue was absorbed by interest on the amount of capital employed—the sum of £1,345,000. Here are some of the biggest items of expenditure: Engineer's department, £481,900; harbourmaster's department, £101,300; dock traffic department, Mersey Cattle Wharf, floating cranes, coaling appliances, etc., £226,700; landing stages, etc., and riverside railway station, £27,700.

Expenditure on conservancy account, apart from interest charges, was approximately £159,000, absorbed by: Surveying, lightships, buoys and landmarks, salvage plant, lifeboats, lighthouses and telegraph stations, steam tenders, removal of wrecks, official charges, etc., £84,221; dredging the bar, etc., £62,591; dredging Taylor's Spit (proportion), £5,070; revetment, Taylor's Bank—raising to original height, £7,432.

Pilot boat rates brought in a revenue of £30,502, whilst expenditure included the following main items: Repairs and maintenance, £8,751; salaries, wages, victualling and miscellaneous charges, £10,016; income tax, £10; annuity fund, being percentage on amount of pilot boat rates, £1,067; cost of collection, being percentage on amount of pilot boat rates, £610; proportion of rent and local rates of office, Canning Pierhead, £327; depreciation of pilot boats (amount set aside), £3,000.

Here is a summary of the outgoings on general repairs and maintenance by the Engineer's Department:—

	LIVERPOOL	BIRKENHEAD
	£	£
Docks, Basins, Graving Docks, Gates, Bridges, Sheds, Streets, Electric Lighting, Gas and Water Service, etc.	140,402	42,032
Buildings, Offices, Yards, Petroleum Depots, etc., let on Rent, Police Stations, Customs Depots, etc.	7,428	2,233
Dockyards, Workshops, Engines and Machinery, Tools, Motor Vehicles, etc.	24,380	7,178
Dredging in River adjacent to Dock Entrances, etc.	63,539	2,011
Damage done to Dock Works	2,760	579
Dredging, Sluicing, etc.	55,941	4,362
Hydraulic Power	62,366	16,264
Sundry Works	1,822	460
	358,641	75,123

An interesting cameo is given of revenue account, enabling a comparison to be made of income and expenditure in the various sections:—Dock traffic department, special and quay rents, haulage of dock traffic, etc., income £67,562—expenditure £63,860; Mersey Cattle Wharf, rates £64,158—expenditure £67,180; floating cranes and cranes on quay at Liverpool and Birkenhead, rates £32,352—general repairs and maintenance £31,706; coaling appliances at Liverpool and Birkenhead £40,610—expenditure £31,863; weighing materials, rates £12,596—expenditure £7,038; railway tolls at Birkenhead and Seacombe £1,327—general repairs and maintenance £12,548; tolls on dock railway £1,188—general repairs and maintenance £7,000; chain and anchor-testing works, income £3,901—expenditure £3,591; passenger toll and other charges at landing stages £16,835—repairs, maintenance and miscellaneous charges £26,053.

As usual, there is a handsome surplus on the dock warehouses, particulars being:—

	INCOME	EXPENDITURE	SURPLUS
	£	£	£
Albert	50,988	26,024	24,958
Stanley	109,876	48,174	61,702
Wapping	22,188	12,220	9,968
Wool	42,430	31,543	10,887
Love Lane ...	6,179	370	5,809
Waterloo	40,824	28,540	12,283
Brocklebank ...	24,424	9,901	14,522
Birkenhead Grain ...	62,259	48,781	13,478
Composite	4,654	293	4,361
Wallasey	51	6	45
Birkenhead ...	2,167	787	1,380
Morpeth	2,000	37	1,962
	368,039	206,680	161,359

Hull and the East Coast

Improvements at Victoria Dock, Hull.

IN connection with the scheme of improvements at the Victoria Dock, Hull, to meet the wishes of the timber-importing trade, the announcement has been made that the London and North-Eastern Railway Company have purchased the site of Earle's shipbuilding and engineering yard to be devoted to standage and bogie lines. The land covers a space of 26 acres and is quadrangular in shape, and adjoins the Company's Citadel Estate to the east end of the Victoria Dock. Earle s yard was taken over by National Shipbuilders' Security, Ltd., in 1932, and closed under the redundancy scheme. The property was dismantled and the site offered for sale in the open market, with the proviso attached that it should not again be utilised for shipbuilding purposes except in very special circumstances. A proposal was made that the Hull Corporation should become a purchaser and provide a modern dry-dock, but this came to naught. Already the L.N.E.R. have a big scheme in hand for the improvement of the Victoria Dock, to which the latest acquisition will prove a very useful extension, and it is estimated will increase the projected expenditure hereabouts to nearly a quarter of a million sterling. The importation of sawn wood from the Baltic and White Sea has grown tremendously, and the additional facilities now projected have been felt an urgent necessity for some years past to enable delays and congestion to be satisfactorily tackled and, if possible, overcome. Considerably over a million loads of sawn wood were imported at Hull last year, and over half a million loads of pit props, etc., in addition—records in the history of the port.

Proposed Protection Works in the River Trent.

The Humber Conservancy Board have had under consideration proposals submitted by the Trent Catchment Board for the erection of stone protection works in the River Trent, one of the two main tributaries of the Humber. The scheme, estimated to cost £150,000, has been approved by the Ministry of Agriculture for grant purposes, and the consent of the Board of Trade has been sought to start the work at two points near Wildsworth and East Butterwick. The Conservancy Engineer, Mr. A. E. Butterfield, reported that the scheme in effect provided for the protection of the banks of the River Trent by the riveting of the concave side of practically every bend in the river from Gainsborough to Trent Falls at the junction with the Humber. The method to be adopted was the depositing of a substantial chalk toe and foundations surmounted by a bank of slag carried to about four feet above low-water mark ordinary spring tides. The object was to prevent erosion and to assist the warping up of the foreshore between the embankment and high-water mark. When the warping process was complete and the foreshore had attained a gradient of approximately one in six, the flood banks would be repaired or rebuilt. In addition to the bends, the work would be applied to a few other places where flood banks were weak and impingement and erosion were taking place. The embankments were to be constructed at low-water mark and would follow the general curve of the river as far as possible. Mr. Butterfield expressed the opinion that the method was absolutely sound, and that when the works were completed considerable improvement should take place in the river. The Works Committee recommended that, subject to the approval of the Board of Trade, no objection should be offered to the carrying out of the proposed works at the points specified or to the other proposals, provided detailed plans are submitted to the Conservancy Board for consideration in due course; but that the attention of the Board of Trade and the Catchment Board be drawn to the point mentioned by the Conservancy that one of the proposed embankments did not follow the line of a training wall recommended by the Conservancy Board's consulting engineers, and that they be asked to give consideration to the matter. The recommendations of the Works Committee were confirmed by the full meeting of the Conservancy Board.

Meeting of Humber Conservancy Commissioners.

At the December meeting of the Humber Conservancy Commissioners it was reported that the Hull Trinity House had nominated as commissioners Captains R. L. Biggins, H. Montgomery, S. R. M. Tyrer, Z. C. Pearson, and E. P. Henson and Commander C. Barron.

The Chairman (Mr. J. H. Fisher, J.P.) announced the retirement of Captains Norton, Collins and Cawthorne, and expressed the Board's appreciation of their work. Captain Norton, who has been on the Board eight years, responding, said that he had had to give up the work on medical advice, and added that "The Trinity House think we ought to have up-to-date members on the Conservancy Board, and have therefore elected six of the younger brethren who have recently left the sea and who should be able to keep you well informed."

The Marine Committee reported that all parts standing above low water of the wreck of the Danish steamer "Neptun," which sank in the vicinity of Middle Whitton Lightship on June 27th last, had been removed, but that as the site of the wreck had now silted up it was impracticable to proceed further with the remaining portion of the wreck. The Committee recommended that the Board pay the contractors £1,200 in respect of the work already carried out on condition that they agreed satisfactorily and without delay to complete the work if and when the remains of the wreck bare out for the balance of £400 of the contract price.

The recommendation was adopted.

Cranage Charges at Hull.

On the question of cranage charges at Hull it has been suggested to the dock owners that the position would be met to some extent if they accepted responsibility for third-party risks at no increase on existing schedule rates. The L.N.E.R. had previously offered to accept responsibility for consequential damage at a charge of five per cent. on cranage account, but this suggestion was not acceptable to shipowners, for the reason that insurance could be effected at a cheaper rate. As the Company were not disposed to amend the proposal, it was suggested that a line of demarcation might be drawn as between shipping and receiving interests, and that in any case, such an arrangement might be put into force for the benefit of those to whom it was acceptable. It was, however, pointed out that considerable use was made of the cranes on a time basis by other than members of the Shipping Committee to such an extent that this was impracticable, and that the Company could only introduce the scheme provided it had the unanimous support of crane users. So many firms are indisposed to accept the scheme that there is no prospect of any change.

Coal Shipments from the Humber Ports.

The quantity of coal shipped by the appliances at the Hull Docks in 1936 was 2,086,381 tons, compared with 2,409,609 tons in 1935; at Grimsby the total was 1,085,027 tons, against 1,119,592 tons, and at Immingham 1,722,218 tons, against 1,809,409 tons. At Goole the approximate quantity was 1,600,000 tons, compared with 1,631,320 tons. The aggregate of the four ports is thus just upon 6½ million tons, and consists of cargo and bunkers, foreign and coastwise, and is 476,300 tons below 1935. The proportion exported to places abroad was 3,041,150 tons, against 3,279,716 tons in 1935, and 3,281,131 tons in 1934. A few years ago, before the coming into operation of the Coal Mines Act, the foreign exports from the Humber exceeded six million tons annually. The shipments of bunker coal last year are estimated at 2¾ million tons. The reduction in exports is attributed to a variety of causes connected with the state of trade and industry in Europe and elsewhere, and the high minimum prices under the Coal Mines Act.

Shipbuilding at Hull.

Although Hull has no shipbuilding yard capable of the construction of large merchant vessels, the Humber district remains the premier centre of the world for the building of steam-fishing craft. Last year the two principal yards launched 35 steam trawlers, mostly of the larger type, with a gross tonnage of 17,276 tons, as compared with 17 and 7,575 gross tons in 1935. In addition, several small coasting vessels, tugs, barges and lighters were turned out.

Appointments.

Mr. H. G. Sayers, Dock Superintendent at the Eastern Docks, Hull, has been promoted to Assistant Superintendent of the Southern Scottish Area, Edinburgh. Mr. Sayers commenced his railway career at Hull in 1907. After the Great War, in which he saw service in Egypt and Palestine with the Royal Engineers, he returned to Hull until 1923, when he became Chief of the Staff section in the district superintendent's office at Sunderland, and later district superintendent. In 1932 Mr. Sayers was appointed Dock Superintendent at Tyne Dock, and remained there until 1933, when he removed to Hull again. His successor at the Hull Docks of the London and North-Eastern Railway Company is Mr. Charles Corps, who for the past three years has been goods agent at Newcastle-on-Tyne.

Mr. Corps commenced his railway service 34 years ago in the district manager's office at Middlesbrough, was yard-master at Hull Mineral Depot for two years and at Dunston-on-Tyne for seven years.

Port of Southampton Topics

A Progressive Year.

WITH an increase over the previous year of eight per cent. in cargo, and four per cent. in passengers, the year 1936 proved a memorable one in the history of Southampton Docks.

The present year seems likely to show even further increases, so that, although it will lack the spectacular features of some previous years, it will probably be a red-letter year.

The great dock extension scheme begun ten years ago is completed, and the coming twelve months will see little in the way of new tonnage coming to the port. But the ordinary traffic of the port is expected to grow still more, for cargo traffic figures have been showing a steady upward tendency for some time, and with the Coronation attracting many overseas visitors to England passenger traffic is expected to reach record proportions.

The cargo figures are likely to be increased to some extent by the opening of certain new works on the New Dock Estate. Particularly does this apply to timber, for new storage sheds and sawmills are nearing completion there.

The largest ship to come to Southampton for the first time during 1937 will be the Orient Line's 23,000 tons "Orcades," sister ship to the "Orion." She will begin her maiden voyage from Southampton in August.

Earlier in the year, in March, the German African Line's "Windhuk" (16,000 tons), sister ship to the "Pretoria," will make her first call outward-bound for the Cape.

Three new motor-ships will be placed in commission on the Southampton-Bordeaux and Southampton-Charente services by the General Steam Navigation Co. in February.

It is interesting to note that during 1936 eight new vessels left or called at Southampton on their maiden voyages. They were the Cunard White Star "Queen Mary," five Union Castle ships—"Stirling Castle," "Athlone Castle," "Dunnottar Castle," "Dunvegan Castle," and "Walmer Castle"—the troopship "Dilwara," and the German African Line's "Pretoria."

The last-named vessel, which called on Christmas Eve on her way from Hamburg to the Cape, made a much longer stay in the port than intended. She ran on a mud bank when leaving Southampton Water, and after defying efforts to move her for nearly 40 hours, returned to Southampton Docks when at last freed, and resumed her voyage to the Cape on December 27th.

Docks Statistics for December.

The December statistics for Southampton Docks proved very satisfactory, and finished the year in fine style.

In every department of the traffic, except cargo, there was an increase, compared with the figure for December, 1935.

There were 238 vessels inward, an increase of 25, and there were 245 vessels outward, an increase of 31.

Tonnage mounted in gratifying style. Gross tonnage inward was 163,744 tons greater than in December, 1935, the total being 1,316,776 tons, as against 1,153,032 tons. Outward, the increase was 169,352 tons, the return for the month rising from 1,145,884 tons to 1,315,236 tons.

Net tonnage advanced by 53,665 tons inward and by 66,181 tons outward. The December totals under this heading were 703,746 tons inward and 715,435 tons outward, as compared with 650,081 tons inward and 649,254 tons outward in the corresponding month of the previous year.

The volume of cargo handled showed a slight decrease, for, although there was an increase of 2,051 tons in exports, there was a fall of 2,735 tons in imports. Inward cargo was 53,679 tons, compared with 56,414 tons in December, 1935, while outward the figure was 37,837 tons, compared with 35,786 tons.

Passenger traffic showed a slight increase. Arrivals numbered 9,232 and departures 11,915, whereas, in December, 1935, the arrivals were 8,983 and departures 11,862. The increases were, therefore, 249 inward and 53 outward.

Overhaul of the "Queen Mary."

The announcement in mid January that the "Queen Mary" would not return to the North Atlantic service until February 17th instead of February 3rd, as originally intended, was not altogether unexpected by those who have been closely concerned with the overhaul of the great vessel, now in progress, at Southampton.

The first overhaul of a liner naturally entails a great amount of work and, apart from alterations and modifications suggested by experience gained in the initial season's working, the turbines have been opened up and carefully examined.

It will be recalled that the overhaul of the giant French liner "Normandie" after her first season's working, occupied a very long time.

The "Queen Mary" overhaul work has been retarded to some extent by the influenza epidemic, for about 13 per cent. of the 2,000 men engaged on her have been ill, and so progress was slowed down. Much more work than was originally intended is being done, and so the decision was made to postpone her re-entry into service by a fortnight.

The liner's two outboard propellers have been changed. The two inboard propellers will, in all probability, be changed in July.

Southampton's Fruit Imports Growing.

If the present rate of progress is maintained Southampton will soon have as great a reputation as a fruit-importing centre, as it now boasts as premier passenger port. Shipments of fruit have grown in astonishing fashion in recent years, and Southampton now deals with the largest part of the citrus and deciduous shipments from South Africa.

In the citrus season just closed 2,580,000 boxes of fruit—oranges, grape-fruit and lemons—were imported into the United Kingdom from South Africa, and Southampton handled more than in the two previous seasons. The total handled at Southampton was 1,869,000 boxes, or rather more than 70 per cent. of the total shipments.

The banana trade with the West Indies and Central America has also grown to very large proportions in recent years, and the special new sheds built at Southampton to replace those burned down some months ago will enable that trade to be developed even more.

Port of London Notes

Port of London Development Works.

Additional work is to be put in hand in connection with the Port of London Authority's £12,000,000 port improvement programme.

A contract has been let for the demolition of the jetties and the construction of a new quay on the north side of the Royal Victoria Dock. The new quay will extend from the old Tidal Basin at the western end to the Canal Meat Berth at the eastern end of the dock. This is a very extensive job and necessitates filling in between parts of the existing jetties, the ends of which will be demolished. Eventually, new sheds, warehouses, rail, crane and other equipment will be installed on the new north side quay, which will be 3,000 ft. in length and provide a needed addition to the port's deep-water berthage accommodation.

A contract has also been let for the further extension of the quay on the south side of the Royal Victoria Dock by approximately 460 ft. eastwards of the site on which a large flour and a provender mill are to be erected by tenants of the Port Authority.

London Shipping.

During the week ended January 1st, 1,138 vessels, representing 990,428 net register tons, used the Port of London. Of these, 501 vessels (795,505 net register tons) were to and from Empire and foreign ports, and 637 vessels (194,923 net register tons) were engaged in coastwise traffic.

* * * *

During the week ended January 8th, 898 vessels, representing 924,522 net register tons, used the Port of London. Of these, 407 vessels (712,153 net register tons) were to and from Empire and foreign ports, and 491 vessels (212,369 net register tons) were engaged in coastwise traffic.

* * * *

During the week ended January 15th, 934 vessels, representing 1,031,615 net register tons, used the Port of London. Of these, 505 vessels (831,102 net register tons) were to and from Empire and foreign ports, and 429 vessels (200,513 net register tons) were engaged in coastwise traffic.

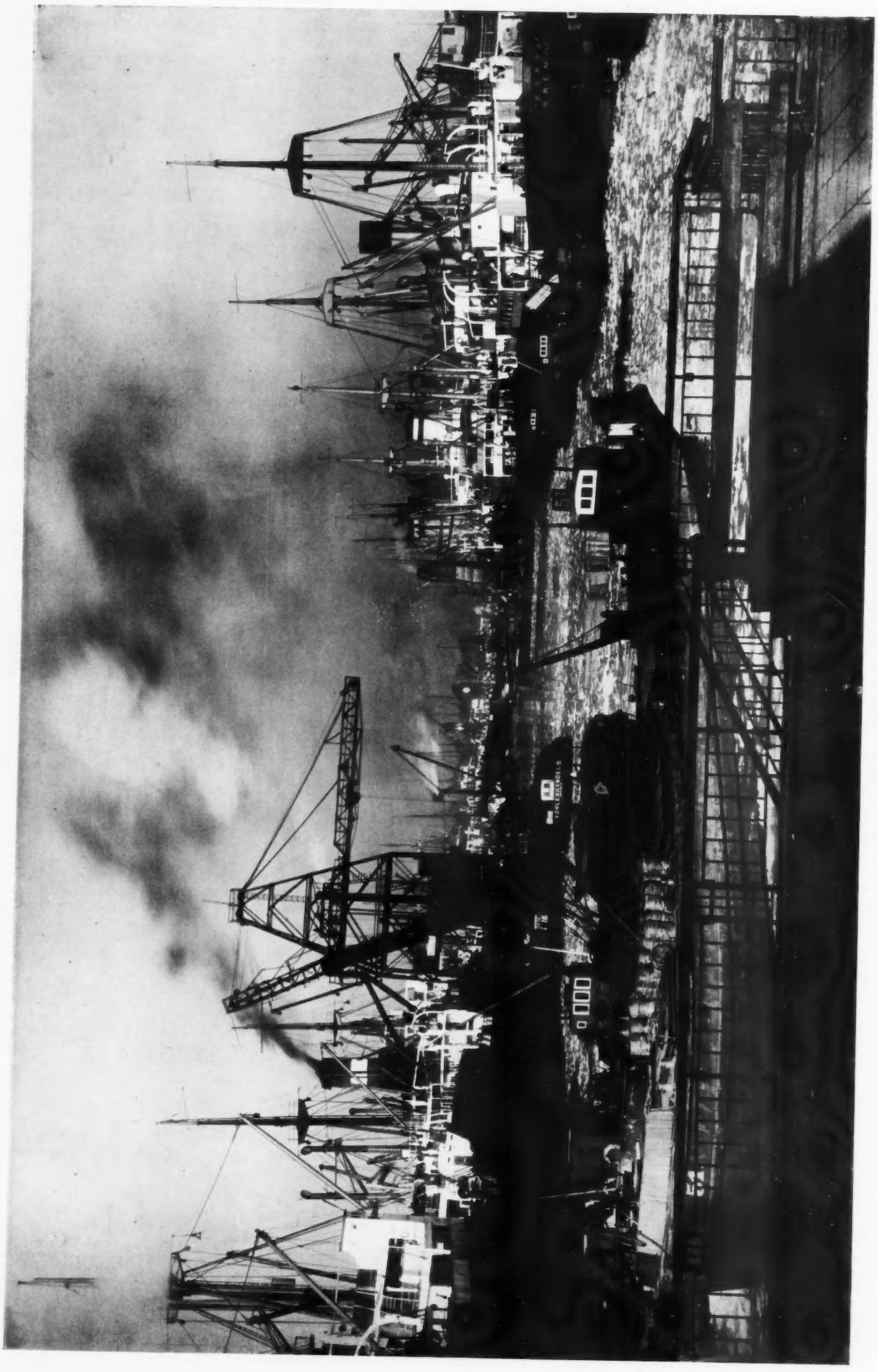
* * * *

During the week ended January 22nd, 1,243 vessels, representing 1,022,147 net register tons, used the Port of London. Of these, 503 vessels (780,537 net register tons) were to and from Empire and foreign ports, and 740 vessels (241,610 net register tons) were engaged in coastwise traffic.

Tilbury Passenger Landing Stage.

Thirty-nine vessels, totalling 400,160 gross register tons, used the Tilbury Landing Stage during the month of December.

Ports of Bremen and Bremerhaven



View of Dock No. 2 in Bremen Freeport.

PORTS OF BREMEN & BR

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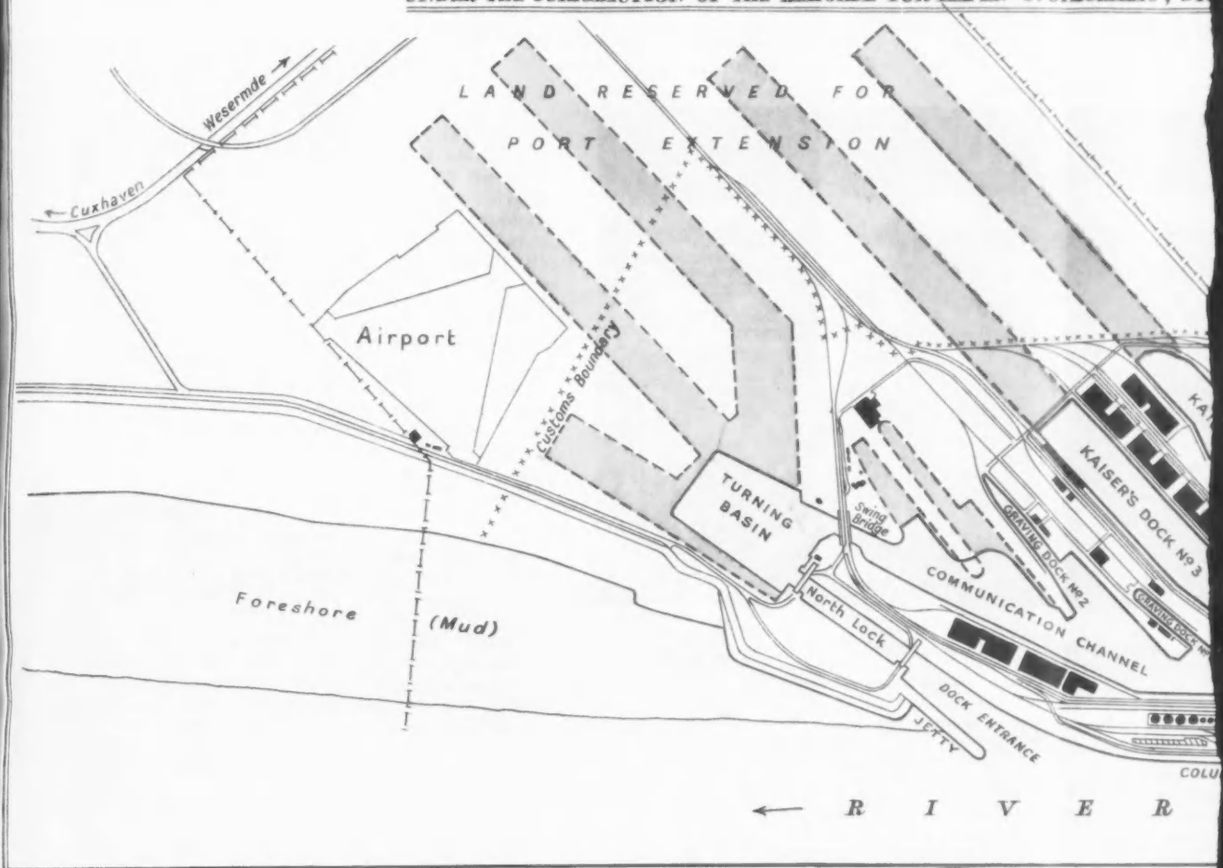

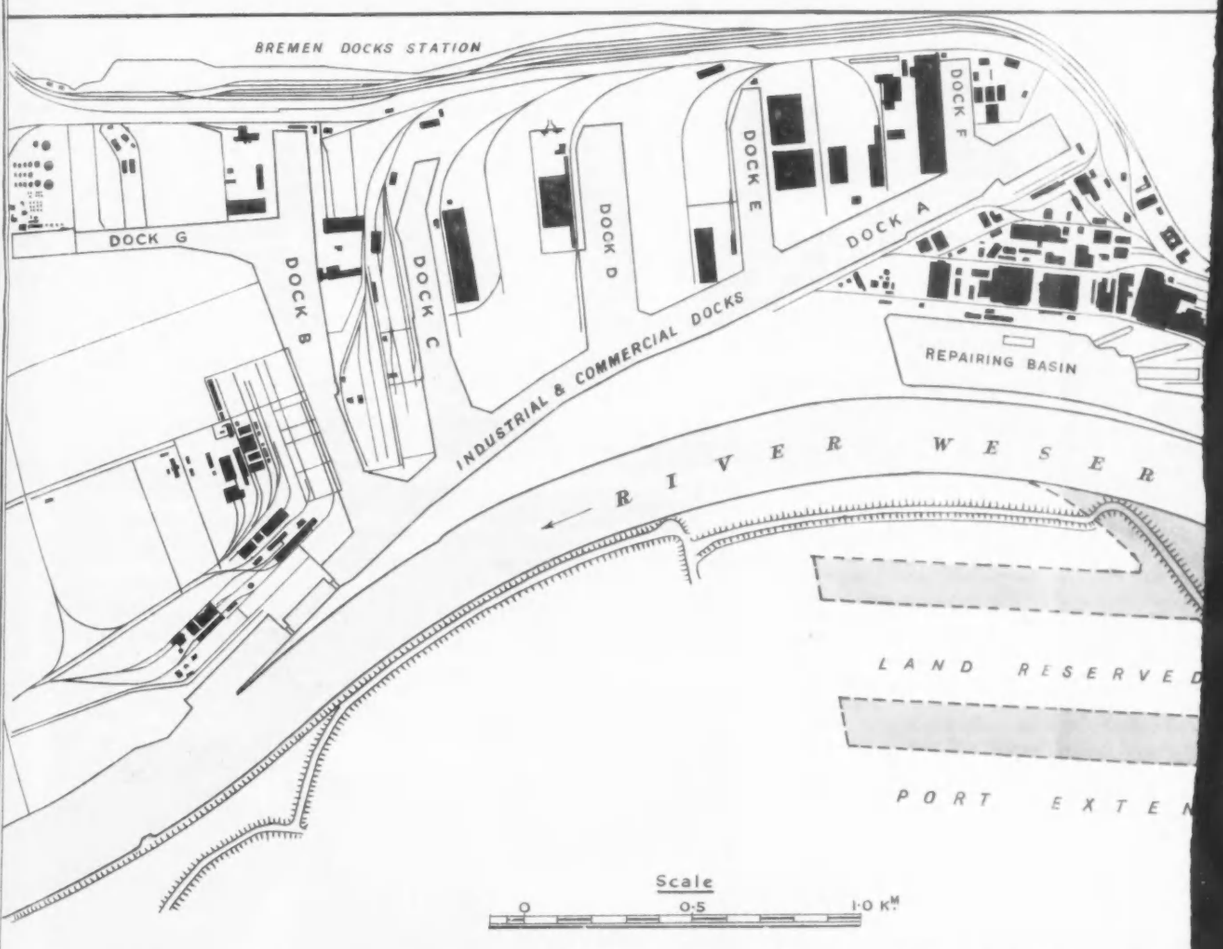

BREMERHAVEN.

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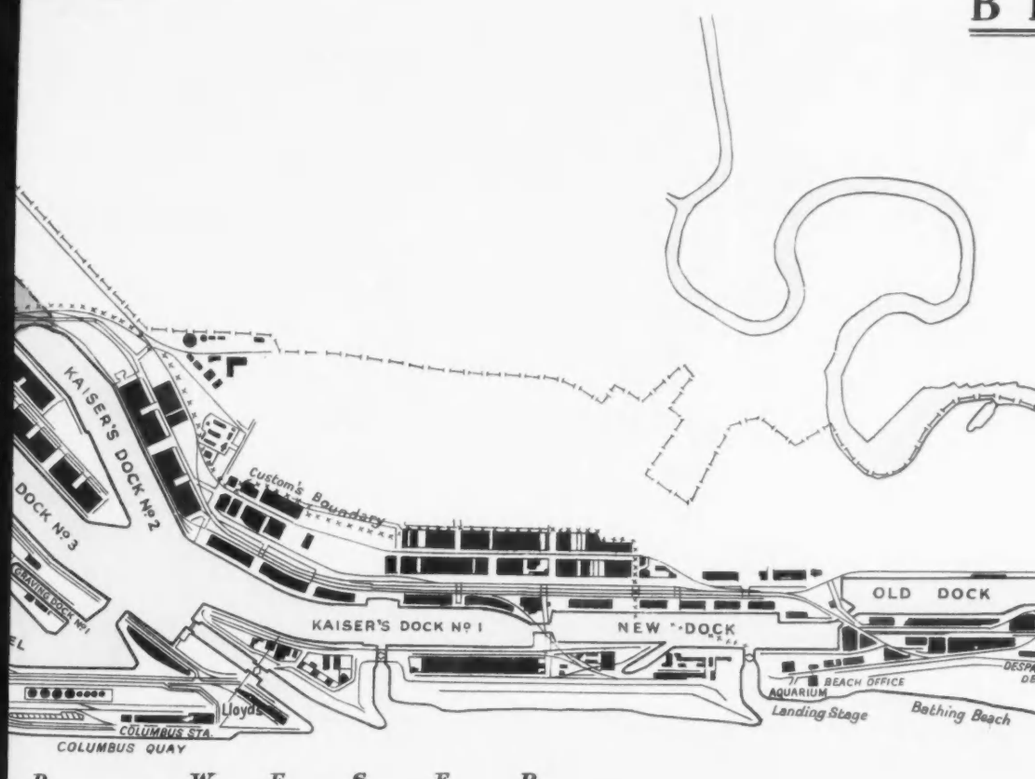

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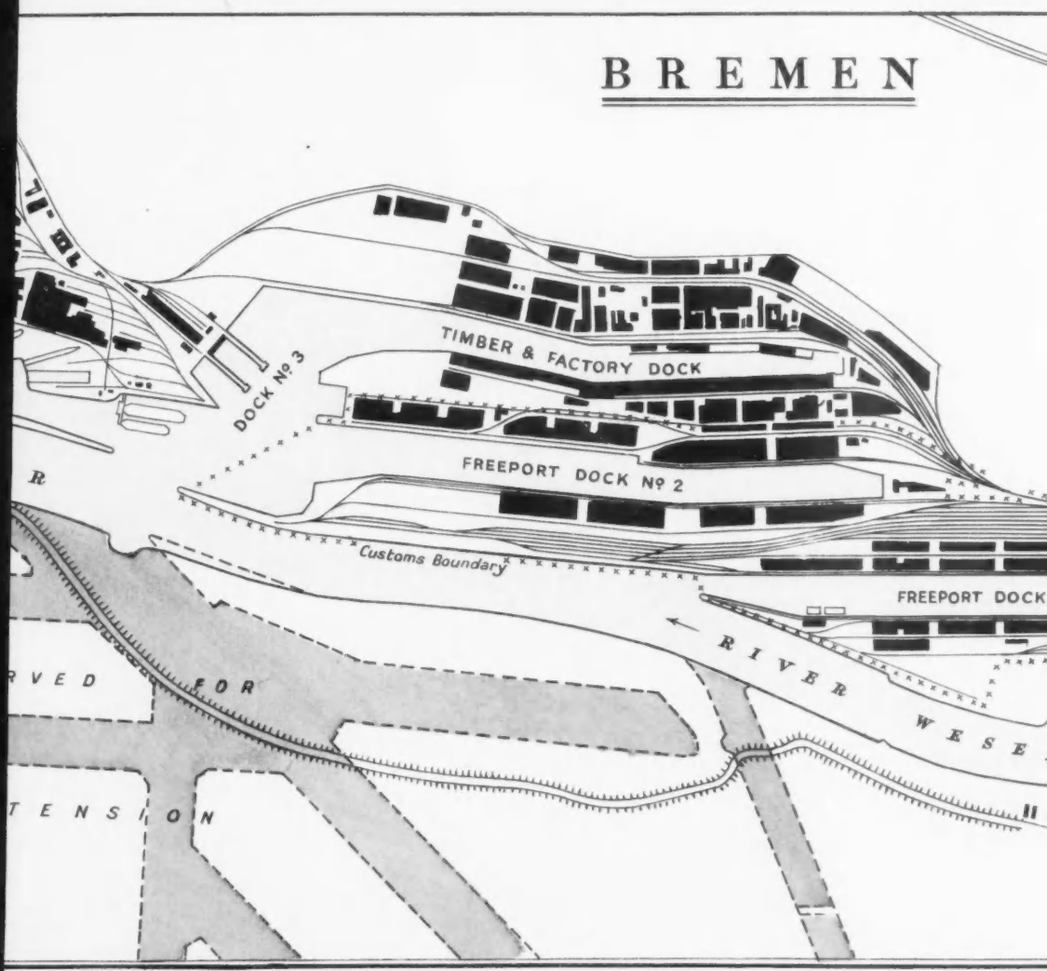

WARD & FOXLOW, LITH., HARCOURT STREET, MARYLEBONE, W.

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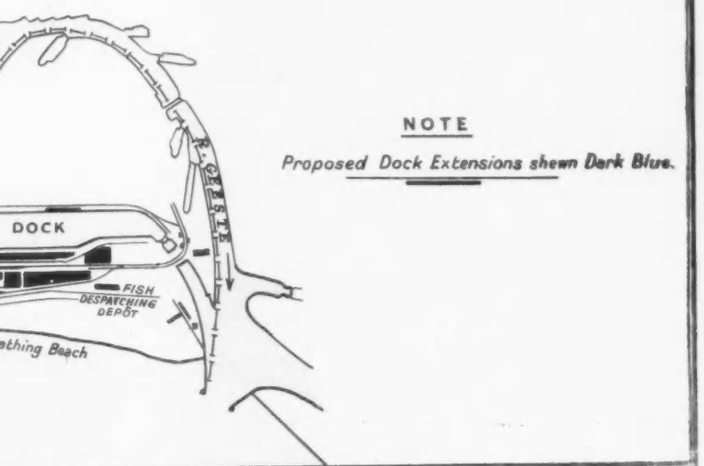
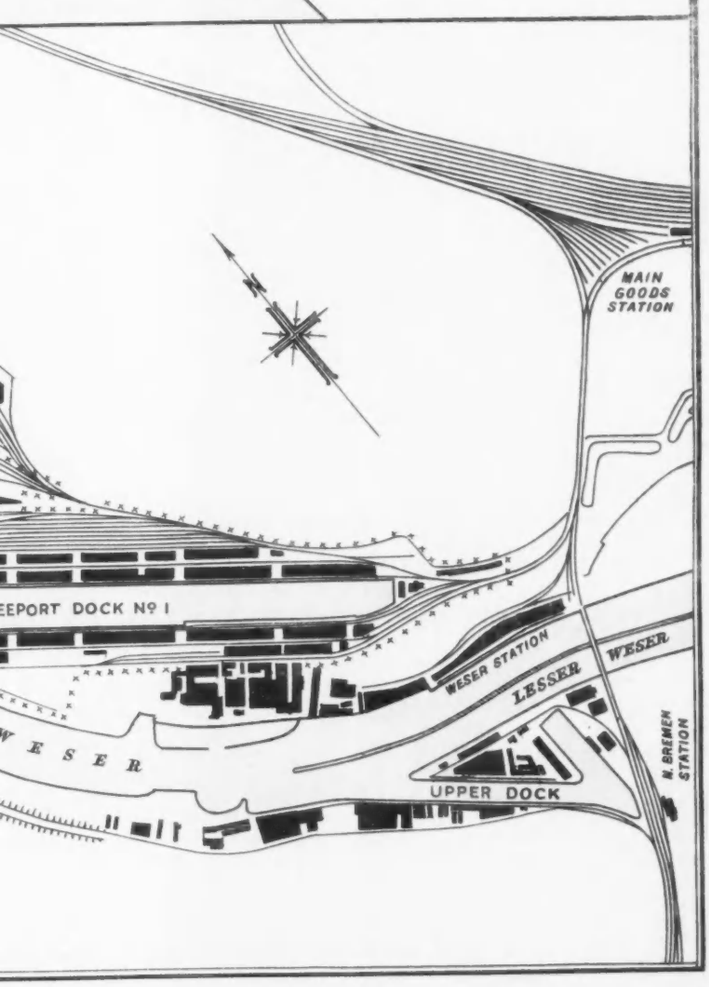
BREMERHAVEN

NOTE

Proposed Dock Extensions shewn **Dark Blue.**





The Ports of Bremen and Bremerhaven, Germany

(BY A SPECIAL CORRESPONDENT)

History.

THE origins of Bremen, the famous old "Hansa" City, go back to almost prehistoric times. A settlement on the lower Weser was known to the tribes north of the Roman Empire, and later on it was the centre of the old Wichmond district which played a great part in the wars of Charlemagne against the Saxons. For the economic history of Bremen the year 965 A.D. is the first notable date. It was in that year that the Emperor granted the first market charter to the town, which was under the rule of the noted Archbishop Adaldag. The charter laid the foundation of the gradual development of Bremen as an important traffic junction, and was the basis for its later sea and river shipping trade, and for its docks. As the township grew, the importance of its merchant population grew. They were successful in gradually securing privileges and rights of independence towards their immediate overlord, especially in commerce and shipping. The occurrence of a famous dispute early in the thirteenth century proves how important the trade of Bremen had become, even at that early time.

Dock No. 2 of the Bremen Freeport. A cotton steamer is being unloaded into Sheds 15 to 17. One-tenth of the North American Cotton Crop can be stored in the spacious sheds of the port.

The town's overlord, Archbishop Gerhard, attempted to levy toll from the Bremen boats. He closed the River Weser with a palisade and with chains, but the Bremen shipowners removed these, and after a protracted and acrimonious, although bloodless, fight, the Archbishop had to give up his intention to place an impost upon the trade of the Bremen merchants. It may be said that from that time dates the independence and subsequent power of the free Hansa town.

The Federation of the Hansa cities grew in the following centuries to one of the mightiest political powers in Europe, controlling overseas trade and shipping all along the Continental coast. They had a large wharf in London, where they were known as "Easterlings"—curiously enough the origin of the term "Sterling." Political rule over the lower Weser had to be combined with secure control over the deposits of silt which threatened the extinction of the town's shipping trade. The spirit of enterprise with which the comparatively small number of inhabitants faced its tremendous task at the beginning of the seventeenth century deserves admiration. Advances made in the building of ships had let to great claims upon the site and quality of a waterway such as the Weser, and in 1618 Bremen built its first dock, not where the docks lie at present, but 20 kilometres below the place where Vegesack is now situated. Above Vegesack the state of the river no longer permitted the safe passage of the larger merchant ships.

Another feudal prince, the Baron of Oldenburg, later endangered the progress of shipping in Bremen by the imposition of a "Weser toll." This remained in force until it was lifted in 1820 by the German Confederation. The political strife and the splitting up of the country into small principalities, which gave its stamp to North-Western Germany in those days, necessitated an enormous effort on the part of Bremen. Out of its own resources it created a port directly on the Atlantic coast—the present-day Bremerhaven. The economic development of Bremen might have taken an entirely different direction if Bremerhaven had remained the only landing place on the lower Weser.

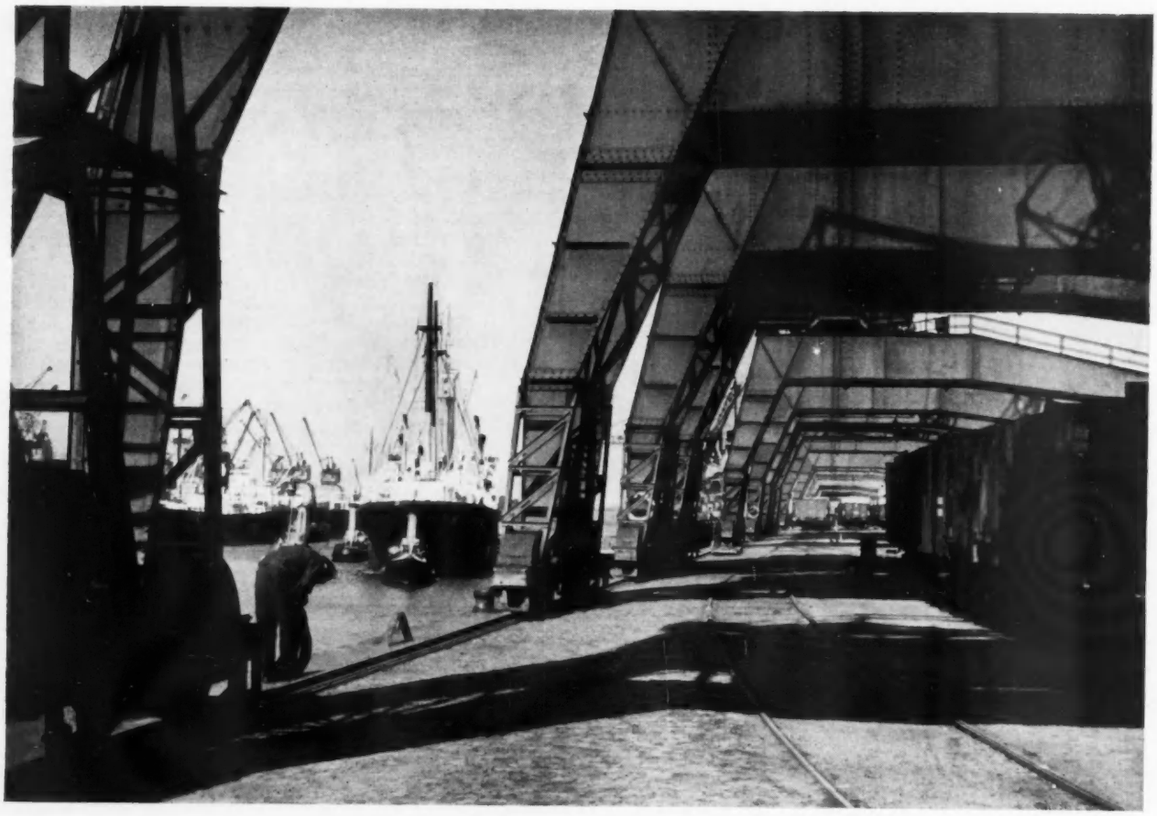
Bremen itself, the traditional centre of commerce, and the home of many shipping undertakings, would have lost its dominant position. An ideal division of functions was, however, achieved between Bremerhaven and the Port of Bremen, the Bremen State Port, as the latter is nowadays called. The problem facing the Bremen municipality was how to safeguard the navigability of the lower Weser as far as Bremen, and thus afford to international shipping all the advantages offered by an important harbour lying deep inland. An ambitious plan for the altering of the course of the lower Weser was submitted to the Senate of Bremen by the Chief Director of Construction, Mr. Franzius. The cost of the scheme was estimated to amount to 30 million Marks. The German states of Prussia and of Oldenburg, which border on the Weser, refused to participate in the undertaking, and Bremen had to shoulder the entire risk. Yet the corporation decided to carry out the plan by itself. It will remain a glorious achievement for all time that this Hansa town of less than 200,000 inhabitants, succeeded in carrying out the alterations. The town's courage was rewarded. The Bremen State Port was soon serving a steadily growing traffic of cargo ships, whilst Bremerhaven developed into the principal port for the Trans-Atlantic passenger traffic. This had the advantage for passengers that they would embark and disembark on the sea coast, thus avoiding a wearisome journey by tender. The division of functions became a uniting factor between the two places, which are entirely inter-dependent. Nowadays, Bremen is unthinkable without Bremerhaven, and vice versa. But for Bremerhaven the town would lack docking accommodation for the giant ocean liners, whilst Bremerhaven could not do without the facilities and the natural headquarters supplied by Bremen to the leading trading concerns, shipping companies, and so on.

Bales of Wool, imported from London, in a Transit Shed in the Port of Bremen.

Gradually the German National Government relieved the small state of Bremen of its enormous responsibilities in regard to the Weser. It was realised that the maintenance of the Weser ports was an asset to all Germany. In the battle against nature and the short-sightedness of its neighbouring states, lasting more than 700 years, Bremen

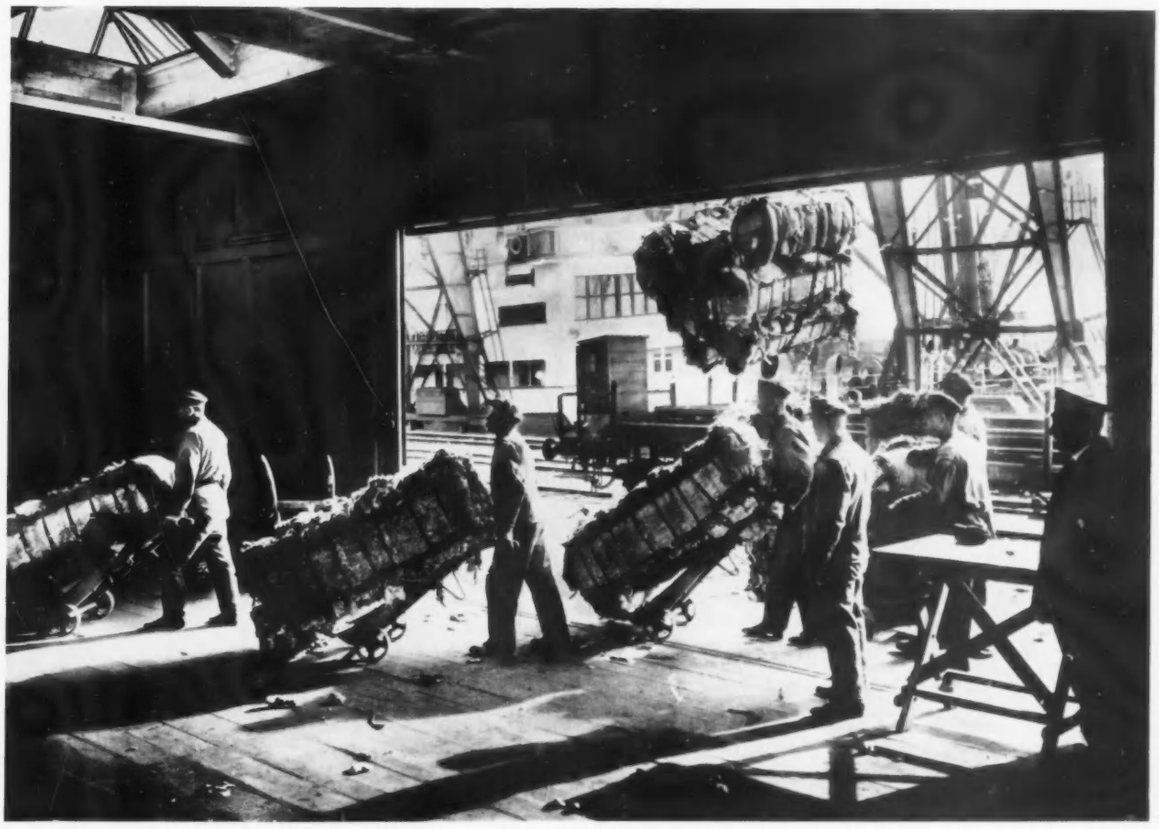
Ports of Bremen and Bremerhaven

The "Potash Dock" (Branch "D" of the Industrial Docks) at Bremen for the unloading of Potash.



View of Dock No. 3 in Bremen Freeport.

Ports of Bremen and Bremerhaven—continued



Dock No. 2 of the Bremen Freeport. A Cotton Steamer is being unloaded into Sheds 15 to 17. One-tenth of the North American Cotton Crop can be stored in the spacious Sheds of the Port.

gained a splendid victory and consolidated its position as one of the most important Continental ports.

Lay-out.

The harbour facilities offered by Bremen to-day, together with those of Bremerhaven, form an entity of 23 units or sections. Coming from the Atlantic ocean we pass ten of these sections along the sea coast, i.e., along the township of Bremerhaven (see Supplement), whilst the other 13 sections are about 22 miles up the river, and situated along the town of Bremen proper (see Supplement). It has already been shown above how these two port groups complement each other in an ideal manner. The ten port sections in Bremerhaven form mainly a passenger port serving the Trans-Atlantic traffic. In addition, they are also well equipped for handling such goods as need not go further inland, and are merely destined for transit traffic from sea to sea. The depth of the basins here is now about 13 metres, and the lower Weser itself, which is the name given to the river for a length of about 22 miles, before its influx into the ocean, has a depth of about 11 metres (14.25 metres at high tide), and a width of approximately 1,500 metres.

Even the largest Trans-Atlantic passenger liners can safely be piloted and docked at Bremerhaven. On the seaward side of the Port of Bremerhaven is situated the famous Columbus Quay, a quay alongside which the largest ships in the world can lie, unaffected by the rise and fall of the tide. Passengers enter express trains directly from the ships, and near at hand is also an air-port for those who wish to fly inland. The ships enter the docks through a gigantic lock, gaining access to a large basin in which they turn (the "Turning Basin" in the Supplement), and are brought by the communication channel to the particular dock in which they berth. Along the communication channel are Graving Dock No. I and Graving Dock No. II, in which the largest boats can undergo repairs, and which is 235 metres long and 42 metres wide. Then follow the large sections entitled Kaiser's Docks Nos. III, II, and I, and then the " New Dock " and the " Old Dock."

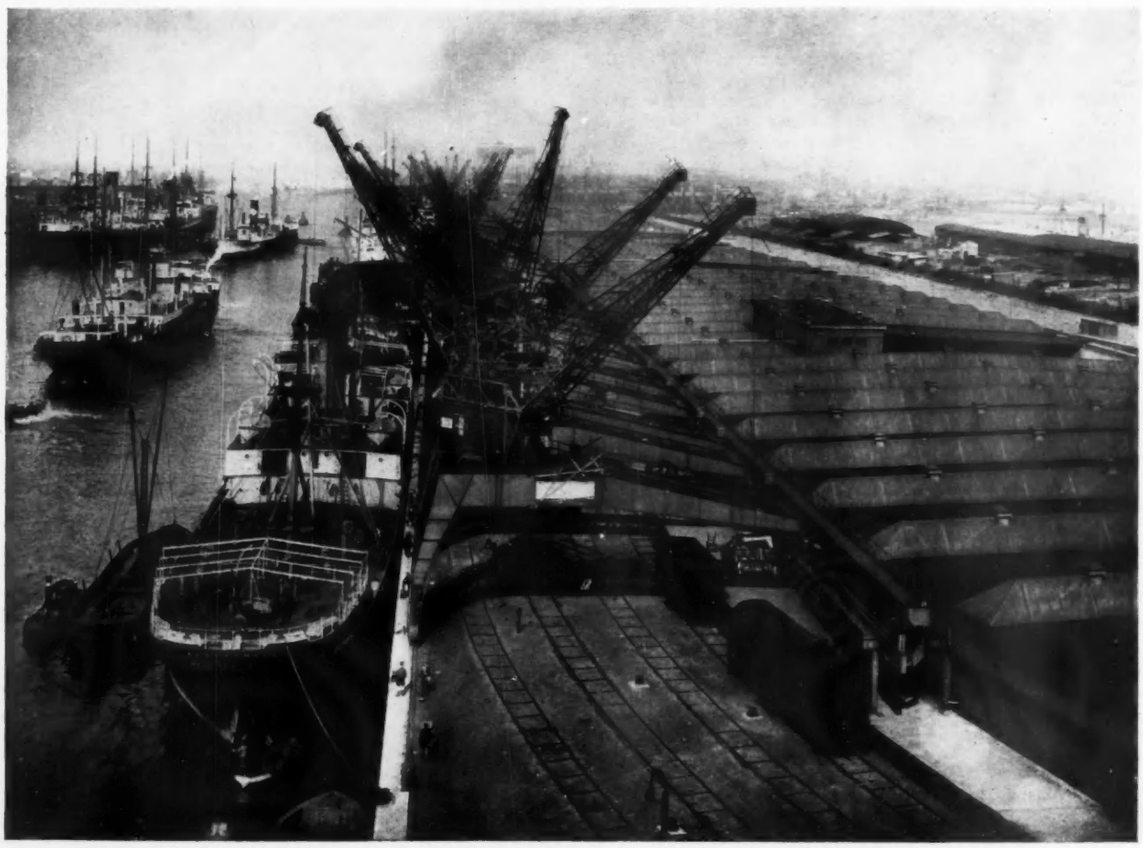
The other thirteen port sections are about 50 kilometres up the river, in the town of Bremen proper, as already indicated. The Bremen State Docks, which chiefly serve the freight traffic, offer the advantage of exceedingly cheap railway rates to the hinterland. The German National Railways have granted exceptionally reduced tariffs for transport from the Bremen State termini to inland centres. For the shipper every shortening of the time taken for land transport, and every reduction in rates, means a profit, since the cost of sea freights is, of course, the same for all Continental North Sea ports, irrespective of the distance up river which the cargo may be able to travel. Here, then, Bremen reaps most clearly the benefits of the river regulation carried out so courageously about a hundred years ago on the lower Weser. At present both the lower and the upper part of the river are waterways suitable for heavy ship traffic. Even the upper Weser, on the stretch to Bremen, is kept at a regular depth of about 9 metres by permanent dredging operations. This depth is quite sufficient for the normal cargo boat. Naturally, the waterway is kept free from ice, even during the most severe winter.

With one small exception, Bremen State Docks all lie on the right bank of the Weser (see again Supplement), and, with the sole exception of the so-called " industrial docks " A to G, they are on the open river. Running on both sides of extensive basins are broad quays, which carry up to four sets of railway lines right to the waters edge. Beyond lie wide loading platforms which lead to sheds, the largest of which is 400 metres in length, and which at their further ends can be approached by rail and road transport. Finally, beyond these roads and railways lie numerous extensive warehouses. This distribution of the space available renders it possible to transfer goods directly from ship to ship, or from ship to railway, while the transit sheds, which serve for temporary warehousing only, are readily accessible from the landward side. The railway network is so dense that there are ten kilometres of railway lines to one kilometre of quay! Goods coming by rail from inland are assembled at a special station, sorted and despatched to the docks for which they are destined.

The Industrial Docks are those first met with on the journey up from the coast, " B " and " G " being reached through a short channel branching off the Weser, and extending into the basin or branch dock " A." From this "A" section there branch off the basins " C," the potash basin " D," and the basins " E " and " F." Further up the river are situated the repairing docks, the Freeport docks I, II, and III, and a Timber and Factory Dock, all accessible from the Weser direct; lastly, we encounter the thirteenth and smallest section the Upper Dock, on the left bank of the river, and the above-mentioned only exception from the other docks, which are all on the right bank of the river. Future plans, which have not yet reached a very concrete stage, provide for the construction of other basins on the left bank, in the manner shown by the dotted lines on Supplement.

Ports of Bremen and Bremerhaven

Bales of Wool being unloaded in Bremen Freeport in Dock No. 1.



The Railway Terminus at the Port of Bremen. The wide Quay, with numerous Cranes and a large number of Railway Sheds placed at right angles to the Quayside Lines, is a feature of this section.

Ports of Bremen and Bremerhaven—continued

Specialised Port Facilities.

Naturally the modern port of Bremen is equipped with the speediest machinery for handling merchandise. There is one special electric crane appliance for the handling of *cotton*, for instance, which makes it possible to unload 15,000 bales of cotton in less than twelve hours. The great advantage of such speedy transfer is, of course, the reduction of the length of time during which ships lie in the docks, thus lessening the harbour dues. The dock sheds cover 265,000 square metres, and are administered by a special company formed for that purpose alone.

Another special appliance is the equipment for dealing with *wheat* carrying ships, four of which can be unloaded at the same time, at a speed of nearly 700 tons of wheat an hour. The storage silos have a capacity of 78,000 tons.

The increasing export of German coal during recent years has been catered for by a most up-to-date plant, whereby waggon-loads of coal are raised on to a new gantry, 80 metres in length.

The Columbus Quay at Bremerhaven with the "Europa" docking.

The Coal Loading Appliance.

The new coal-loading equipment has been erected alongside the Industry Dock C on the property of Messrs. Roechling Bros., who have formed a subsidiary company to run this appliance in closest co-operation with the authorities. Incoming ocean-going ships anchor along the far side of the basin, and between them and the quayside there is space in which a lighter can operate. The loading gantries, which had existed before the new coal appliance was installed, span a distance of 54.2 metres length, and five tracks of rails pass below them. The new gantry makes it possible for the cranes to reach any ocean boat and the lighter, and also to cover the entire depth of the siding and storage space on the quay. The depth of the water in front of the far quay, at the lowest level (for ocean-going liners) is 8.50 metres. The depth for the lighter is also ample. The new plant consists of (a) the gantry or bridge construction proper, with its supports and driving machinery, (b) a special crane with tip-over platform, and (c) feeding and conveyor units. The framed girder of the gantry has a height of six metres and a width of 7.5 metres. It extends at each end by 13 metres beyond the distance previously covered by the old gantries (54 metres), and has thus a total length of 80 metres, or about 250 ft. There are two supports, each of which rests again on two bogies of a total length of 18 metres, running with 12 wheels upon double rails mounted upon concrete foundations and piles. The maximum pressure upon the wheels of these double rails reaches 56 tons per wheel. The two bogies are driven by electric current of high power. They proceed uniformly and give to the gantry a speed of 15 metres per minute. Special storm safety devices in the centre of each support automatically prevent any movement of the bridge, even in a high wind.

The special crane can be manœuvred over the entire bridge. It has a fixed section of 18.5 metres length, and the coal taken up by its grabs is automatically weighed by a rope-pulling scale built into the crane. When worked on the tip-over system, the crane will lift 47 tons with an average unloading stretch of 14.5 metres. Both for grabbing and for tipping, the crane has special rope drums, and without any loss of time the operator can switch over from one to the other method of working.

The crane lifts the platform, with railway waggons which have been driven on to it, high up above the gantry, and puts it into such a position in relation to the ship that the coal begins sliding while the waggon is only moderately inclined towards the ship. A special vibration motor on the platform maintains the flow of coal at an even speed. Pieces that have become stuck in the waggon, or have frozen on to the waggon walls, are automatically dealt with by "tooth-pick" poles, which come down from the crane into each railway waggon.

The conveyors, which form the third component part of the coal-handling plant, are only put into operation if a whole railway train has to be emptied into the ship. The main feature of the conveyor system is a gigantic ribbon of steel chains, held together on a flat steel surface so as to make a band of about three feet in width. Upon this band are hung, closely spaced, steel "cells" or hoppers of 500-litres content each; the cells are pivoted on axles, and so constructed that they do not lose their coal content during the entire journey from the railway train on the quay side to the "elephant's trunk" of steel, operated from the centre of the gantry, which eventually leads the cells into the ship's coal bunker. Springs prevent the falling out of lumps of coal during the journey and on the elephant's trunk, but when passing the lowest point of the trunk the cells empty automatically. Every single part of the system is movable in all directions, can be shortened or lengthened, and the entire appliance is a miracle of constructive ingenuity. It has been called "the giant robot," and the terms used for its description appear justified if it is realised that the appliance can handle between 100 and 200 tons of coal per hour, or about 4,500 tons in twenty-four hours, and that this output is increased when the tipping method is worked. In that case 16 waggons can be handled in each hour, which means 320 tons of coal, or 260 tons of coke. It took a few weeks at first before the operators had mastered the entire range of advantages offered by the new plant. Now they have become so familiar with its running that on days of great pressure as many as 18 railway waggons can be dealt with in an hour, and if shifts are changed, and conditions in the boat are satisfactory, records of 20 waggons per hour have been achieved!

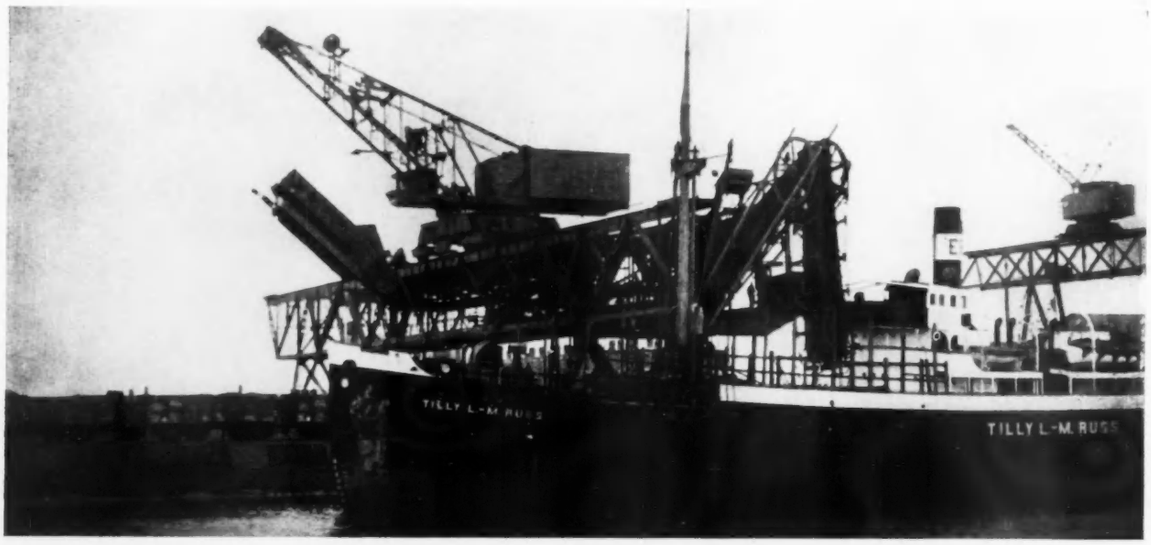
The port authorities claim that coal is handled so carefully with the aid of the new appliance that piece-coal loaded with it fetches a price

The new Coal Unloading Gantry and Crane, described in the article.

Ports of Bremen and Bremerhaven

Special Appliances in the Industrial Docks at Bremen, for the unloading of Flour.

The Historic Old Warehouses along the Upper Weser.



The New Coal Unloading Gantry and Crane, described in the article.

Ports of Bremen and Bremerhaven—continued

of about 10 to 15 per cent. more than the same type of coal brought into the boat by other methods.

The Potash Plant.

Lastly, mention should be made of the Industrial Dock D, where the German Potash Syndicate has special equipment to handle its products. The outfit consists of three transporter units. During an eight-hour shift 5,500 tons of potash can be moved, and in six directly communicating warehouses 120,000 tons can be stored.

The importance of Bremen as a *fishing port* should not be overlooked, although Wesermünde is the more important centre for fishing craft. The herring fleets have their headquarters on the lower Weser, and Vegesack is a centre for drift-net fishing. That Bremen itself is the headquarters of many important German shipping companies, including the "North German Lloyd," is well known. The shipbuilding industry is also represented by large undertakings. In export trade Bremen is famous for its cotton exchange, and tobacco is another commodity extensively handled in this German port.

A View of the Old Port of Bremen, with fine Historic Buildings, along the Upper Weser.

Enlargement Plans.

The improvement schemes intended by the Port Authorities have already been referred to. As will be seen from the Supplement, they are ambitious, and it may take considerable time before they can be commenced. In the meantime, however, certain important extension work has already been carried out, and continues to be done. This work is described below.

The Extension in Freeport Dock No. I.

The continuous development of traffic in Docks I and II in the Freeport of Bremen has recently necessitated improvement work on a large scale in Dock I. (Freeport Dock No. I in Supplement). In fact, the entire basin and the quays of this dock are being reconstructed. From lessons learned in the building and running of Dock II, three requirements had appeared to be essential for the new reconstruction work. Dock I would have to provide safe mooring for all incoming boats by an increase in the depth of the basin; speedier and improved railway feeding services obtainable by an increase in the quay rail tracks; and a speeding-up of all loading and unloading operations by the installation of electric cranes of maximum capacity and working speed. All three requirements, moreover, had to be met at moderate cost, and as much use as possible had to be made of the older and simpler port equipment which existed before the reconstruction.

The improvement work was commenced in 1933, and is almost complete. Its final stages will be carried out during 1937, and by the end of this year the Harbour Construction Authorities hope to finish their work at Dock I. The depth of the basin has been increased to 11 metres, and the quays have been entirely re-built, especially on the southern side of the dock. Lastly, some 32 electric whipping cranes of the latest construction, of 3-ton capacity, and very quickly handled, were installed. By making the south quay wider by 24 feet, the basin itself has been reduced from its former width of 120 to 112 metres. As the north quay is to be similarly widened in the course of the reconstruction work which still remains to be done, the dock will eventually have a total width of 104 metres. This narrowing, however, is considered to be without any detriment, and will make no difference to any of the boats in the European traffic. In the older part of Dock I, which is used only by the large overseas vessels, the width has always been 100 metres, without any trouble being caused by this feature of the basin. The widening of the quays has enabled the Construction Authorities to increase railway traffic considerably, and it is certain by now that on the south side of the dock the general total which can be handled by rail and ship has been increased from 35 to 40 per cent., as compared with the total before the widening of the quays and the installation of the new cranes.

The necessary finance for the three improvements was in 1933 provided by public funds created for the reduction of unemployment, but the second stage of the building work, recently commenced, and involving an expenditure of 4.55 million Marks, was mainly financed by Bremen itself, with Government authorities providing only the smaller proportion.

The New Loading Cranes.

Recent improvement work included finally the construction of two large crane gantries, with carrying capacity of 18 tons each, and a length of 80 metres for the crane track. The width of the bridges from pillar to pillar is 50 metres, and the width of the actual usable bridge-way is 20 metres. The construction is so planned that a number of cranes can deal simultaneously from the bridge with one ship. The cranes are of a novel design, permitting quick unloading from boat to railway waggon. They are of the whipping type, and can be brought close to the ship at port-hole height. The authorities are at present considering adding to the efficiency of the gantries by installing endless conveyor belts. The roadway across the gantry runs at a height of 18 metres above the port level. Both bridges have been mounted upon the new part of the quay of the Industrial Port A, which has a total length of 680 metres, the entirely new portion of the quay being 250 metres. The bridge foundations were not erected by the old method of timber or reinforced concrete piles, but Mr. Hacker, Director of Harbour Construction, employed the new Becker-Hacker method for steel piles in co-operation with the United Steel Works of Germany.

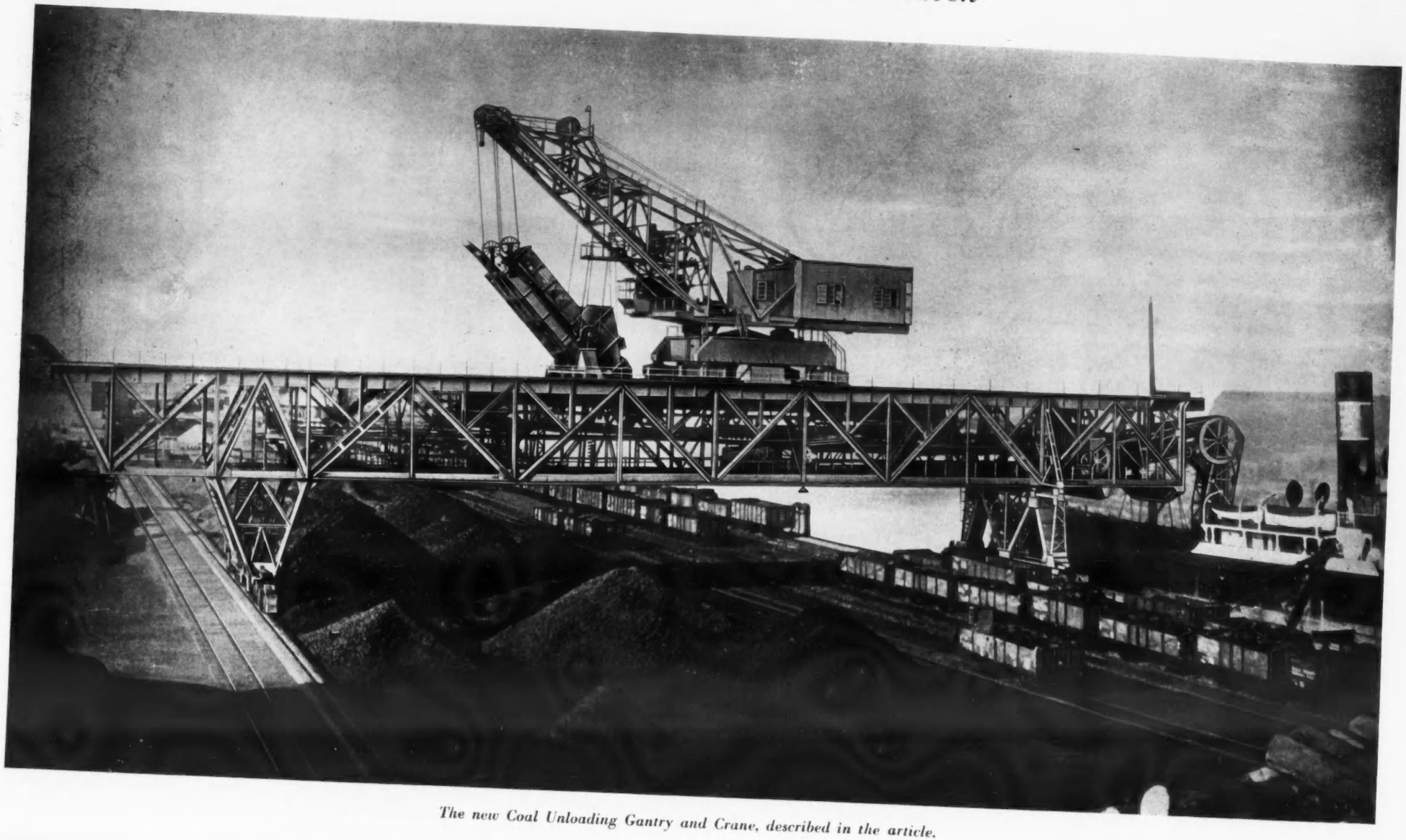
Development of Passenger and Freight Traffic.

The manifold restrictions on international trade have perhaps had their greatest influence upon the large ports, and during the worst crisis years the turnover of the Bremen docks suffered heavily. Only during the past two or three years have conditions improved, though the highest figures, achieved in 1929, have not yet been recovered. Thus the tonnage of passenger boats arriving and leaving the port in 1925 was 5.8 million tons, in 1927—7.9 million incoming, and 7.8 million tons outgoing; and in 1935 the figures for both incoming and outgoing traffic amounted to 6.94 million tons. In 1925 goods imports totalled 2.8 million tons, and exports 1.5 million; two years later, the figures increased to 3.9 and 1.6 million tons. The returns for 1935 show that imports fell to 2.1 million tons, but that exports rose to 3.1 million. The most outstanding feature was the recovery of the export trade in 1935, which was mainly due to the coal trade, and an increase in the transport of manufactured goods. During the first quarter imports dropped from 693,000 tons to 679,000 tons, and exports, at 790,000 tons, failed to equal the previous year's figures of 1 million tons.

Comprehensive figures covering the 1936 turnover are not yet available, but according to the most recent monthly report, arrivals of raw materials, and total arrivals, were higher than last year.

The transport of ore, coal, fertilisers and wood showed a heavy increase. Exports of manufactured goods rose during the first quarter from 248,840 tons to 203,673 tons, and after suffering a temporary decline in June, recovered subsequently, and it is expected that the previous year's levels will prove to have been reached again by the end of 1936.

Ports of Bremen and Bremerhaven



The new Coal Unloading Gantry and Crane, described in the article.

Ports of Bremen and Bremerhaven—continued

The accompanying tables illustrate the development of traffic and its importance since 1933 in the Ports of Bremen and Bremerhaven and the lower Weser, although the figures for 1936 are not, unfortunately, yet available. But the increased traffic, and particularly the greater export of heavy goods, which was already visible in the figures for 1935, has certainly continued and developed in the past year.

ORIGIN OF BREMEN IMPORTS

COUNTRY OF ORIGIN	QUANTITY IN QUINTALS 1933	1934	1935
Other German Ports ...	4,130,864	4,267,906	5,467,456
Europe, except Germany ...	7,079,539	9,971,292	8,226,630
Africa	1,452,116	1,845,903	1,926,619
Asia	2,382,700	2,773,986	1,574,052
America	9,817,387	9,204,854	6,919,760
Australia	760,207	639,128	377,866
	25,622,813	28,703,069	24,892,383

	VALUE IN THOUSANDS OF MARKS 1933	1934	1935
Other German Ports ...	79,654	87,042	108,224
Europe, except Germany ...	210,639	241,799	246,888
Africa	35,509	48,113	67,959
Asia	50,033	59,623	59,232
America	412,401	300,371	280,232
Australia	85,693	91,935	42,658
	873,929	828,883	805,193

The Roland Mill, a flour milling plant alongside the Timber and Factory Dock.

BREMEN IMPORTS BY GROUPS OF COMMODITIES

	QUANTITIES IN QUINTALS 1933	19 4	1935
Total Imports ...	25,622.813	28,703,069	24.892,383
Gold, Silver, Uncoined Bullion	719	320	253
Goods	25,622,094	28,702,749	24.892,130
Of which :—			
(a) Foodstuffs ...	9,826,096	11,757,365	8,868,874
(b) Commercial Goods	15,795,998	16,945,384	16,023,256

BREMEN IMPORTS BY GROUPS OF COMMODITIES

	VALUE IN 1,000 MARKS 1933	1934	1935
Total Imports ...	873,929	828,883	805.193
Gold, Silver, Uncoined Bullion	12,339	1,844	805
Goods	861,590	827,039	804,388
Of which :—			
(a) Foodstuffs ...	221,861	235,047	212,385
(b) Commercial Goods	639,729	591,992	592,003

BREMEN TRAFFIC BY HOME AND FOREIGN FLAGS

ARRIVALS

	1933 No. of Boats	1933 Tons	1934 No. of Boats	1934 Tons	1935 No. of Boats	1935 Tons
Total	6,413	7,237,288	6,873	8,146,704	7,110	8,289,866
Of which : German ...	5,096	5,329,605	5,491	6,079,447	5,879	6,505,541
Of which : Bremish ...	2,707	3,883,524	2,853	4,023,464	2,818	4,171,613
Foreign ...	1,317	1,907,683	1,382	2,067,257	1,231	1,784,325

DEPARTURES

	1933 No. of Boats	1933 Tons	1934 No. of Boats	1934 Tons	1935 No. of Boats	1935 Tons
Total	6,512	7,250,909	7,120	8,134,572	7,397	8,264,428
Of which : German ...	5,207	5,356,774	5,749	6,054,114	6,157	6,470,149
Of which : Bremish ...	2,739	3,903,016	2,885	3,989,587	2,949	4,177,356
Foreign ...	1,305	1,894,135	1,371	2,080,458	1,240	1,794,274

Canadian Notes

A New Shipping Record at Montreal.

An all-time record in the combined total of ocean and coastal vessels entered has been established at the Port of Montreal. Up to November 12th, ocean and coastal ships entered totalled 1,928, and the season had yet to run three or four weeks. During 1935 the total was 1,804, and in the previous peak year, 1934, 1,855 vessels were entered. In addition to the ocean and coastal ships, a large number of lake and river steamers enter Montreal Harbour, totalling 3,920 vessels during 1935.

Montreal, meeting point for ocean-going and Great Lakes steamers, is a perfectly-equipped port. Its wharves of a total length of nearly ten miles provide several berths for the accommodation of thousand-foot ships. The harbour is provided with a floating dry-dock, and is equipped with both electric and steam locomotives for the rapid handling of freight. The capacity of Montreal's grain elevators is over 15 million bushels, and the sheds, about 13,000 feet in length, can accommodate 300,000 tons of merchandise a week. Situated 1,000 miles from the Atlantic Ocean, it is one of the most important shipping centres in North America. During 1928 grain shipments from Montreal amounted to 211,295,379 bushels, representing about 45 per cent. of the tonnage handled at the port. Of late years, shipments of other commodities via Montreal have made large gains, and during 1935 the situation had altered to the extent that the grain exports were only 10 per cent. of the total tonnage.

Oil has become a prominent article of commerce at the Port of Montreal during the past ten years, increasing from 625,382 tons in 1925 to 2,081,264 tons in 1935. In one section of the port is what might be termed almost a separate oil harbour, where several oil importing and refining companies are located, each served by a small industrial wharf piped for the rapid unloading of crude petroleum and gasoline in bulk from large ocean tankers.

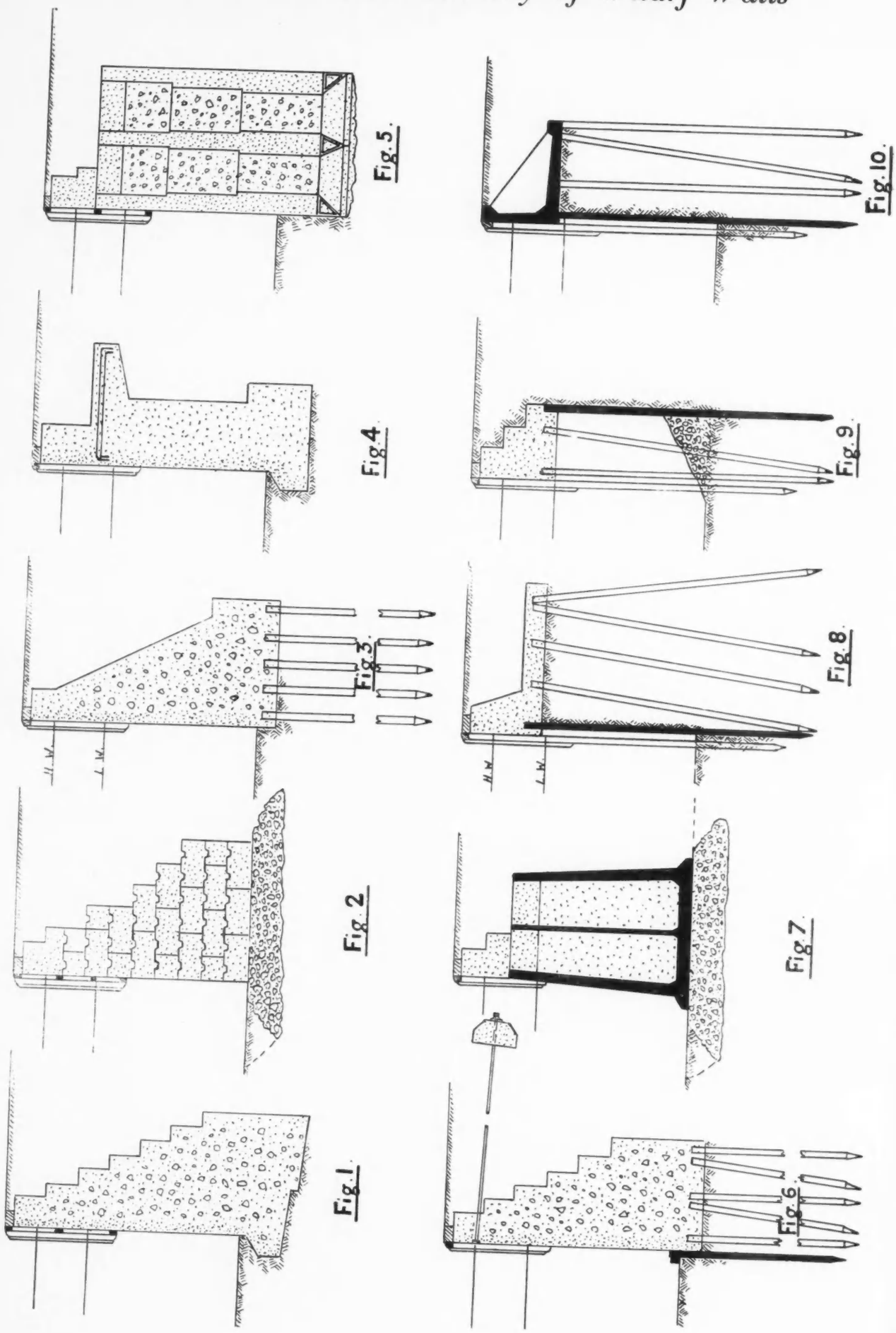
Overseas Export Clearances and Imports of Wheat into the United States.

During the week ending November 27th, 1936, the overseas export clearances of wheat amounted to 4,779,897 bushels, while imports into the United States for consumption and milling in bond were 879,000 bushels. The total is 5,658,897 bushels, as compared with 6,465,506 bushels for the previous week, a decrease of 806,609 bushels, and when compared with the same week in 1935, an increase of 1,574,886 bushels.

The following table shows the export clearances of Canadian wheat by ports from August 1st to November 27th, 1936, along with the comparative figures for the same period in 1935-36, and imports into the United States for consumption and milling in bond (in bushels) :—

Overseas Clearances	1936-37	1935-36
Montreal	26,500,808	21,793,579
Sorel	11,009,104	4,013,667
Three Rivers	3,787,995	—
Quebec	1,674,171	821,228
Fort William and Port Arthur ...	407,576	—
Halifax	—	6,631
United States Ports	7,759,355	6,796,000
Churchill	4,293,501	2,407,000
Vancouver-New Westminster ...	12,853,257	10,772,573
Prince Rupert	562,614	—
Total Overseas Clearances ...	68,248,381	46,610,678
Imports into the United States		
For consumption and milling in bond for re-export	21,266,413	19,099,433
Total Overseas Clearances and United States Imports to date ...	89,514,794	65,710,111

Construction and Stability of Wharf Walls



The Construction and Stability of Wharf Walls

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WHARF and wet dock walls are of various types depending upon the nature of the ground, the method of construction, the maximum depth of water required alongside, the probable superloads on the wharf, the exigencies of the site, and the cost of construction and maintenance, the two latter items being generally the main factors in deciding what type of wall should be adopted.

The simplest type of wharf wall, which is commonly used on river and canal banks, consists of either creosoted timber or reinforced concrete sheet piling, anchored back to the land by steel tie rods fixed to a pile or block of concrete buried in the ground.

Along the line of the wall, king piles with ordinary points are first driven well down about 12 ft. apart, and on the front and back of these piles at the coping level, and also at the water level, longitudinal walings are bolted, and between these two lines of walings, the sheet piles are driven; these are usually tongued on one side, and grooved on the other, and the shoes are wedge shaped, the bottom edge of the shoes having a slope of about 1 in 8.

The sheeting is driven against the king piles on each side, and in the centre of each 12-ft. length a special closing pile is driven to wedge the sheeting together. From each king pile a steel rod 1½ in. to 2 in. diameter passes through the pile head below coping level, and is attached to either a pile or concrete block, sunk in the ground from 20 to 30 ft. from the face of the wall. Sheet piles are usually 9 in. by 4½ in., 12 in. by 6 in., or 14 in. by 7 in., or may be square in section, as are the king piles, according to the depth of water required alongside the wharf.

For deep water quays, say up to 40 ft. at L.W.S.T., the mass concrete, monolith, and caisson types of walls are the most suitable; these are all gravity walls, the maintenance of which is practically nil, with the exception of repairs to the timber fenders.

In Canada and in the United States of America where timber is cheap, the lower portions of wharf walls, up to a few feet above L.W. level, are formed of either rough or squared timber baulks spaced from 6 to 8 feet apart each way, notched to one another where they cross, and spiked together; these timber cribs may be so much as 120 ft. long, 30 to 40 ft. wide, and 30 ft. high; they are stepped up at the back, reducing the width to from 20 to 30 ft. at the top. When completed they are floated to the site of the wall, and sunk by filling them with large stones, the site having been previously dredged and levelled to receive them; should the ground be bad, the sites are sometimes piled. In some cases the front portion of the cribwork for a thickness of from 8 to 10 ft. is filled with concrete in the proportions of 1 to 4 or 1 to 6 of aggregate, which is lowered in skips having hinged bottom doors, which should only be opened close to the depositing level. The upper portion of the wall consists of mass concrete deposited inside shuttering.

Due to the ravages of Teredo navalis, and Limnoria terebrans, the life of this type of wall is limited to from about 30 to 40 years, unless the face is protected by concrete.

Large brick-built wharf walls have been constructed at the Kidderpur Docks, Calcutta; they are from 46 to 51 ft. high and 35 ft. wide at the base, but hollow inside, the thickness at the face being about 5 ft. 10 in., and at the back, which is stepped up, from 3 ft. 9 in. to 4 ft. 2 in., cross partitions 3 ft. 9 in. thick are constructed inside at about 6 ft. 3 in. apart, and arches are formed between these.

In some cases in which the ground is of rock, much thinner walls can safely be built as at Liverpool Docks, where there is a wall 41 ft. high, acting as a facing to soft sandstone rock; this concrete wall has an average thickness of 3 ft., but at 20 ft. intervals at the back it is keyed 4 ft. into the rock, by dovetail-shaped buttresses 5 ft. wide.

The Penzance Dock walls are 27 ft. high, 2 ft. 6 in. thick at the top, and 10 ft. at the base, with a batter on the face of 1 in 12; they are of granite rubble in blue lias lime mortar, and are founded on hard rock; there is a 2-ft. thickness of puddle clay at the back, and the filling is of broken rock and silt; the thickness of this wall is $\frac{1}{2\cdot7}$ of the height.

Similar thin walls have been successfully built at Sunderland and at other places where the ground is of rock, but where it consists of alluvium, and thin walls have been constructed, there have been several failures.

A quay wall on the Weaver navigation 48 ft. high and 14 ft. 6 in. thick at the base, built on clay and supported on timber piles 22 ft. long, which passed through a bed of sand from 3 to 6 ft. thick, down to rock, gave way, due to the slipping of the clay. When the wall began to move forward, iron tie rods were fixed to the wall, and anchored to concrete blocks 20 ft. by 20 ft. by 16 ft., buried in the ground, and carried on piles, some distance behind the wall, but this precaution did not save the wall from collapsing, the blocks being dragged along by the wall.

The old Limerick Basin walls, which were 28 ft. high, 5 ft. 2 in. thick at the top and 8 ft. 4 in. at the base, having a batter on the face of 1 in 20, and carried on a timber platform resting on piles, afford a remarkable example of thin walls standing fairly safely for 38 years.

The walls were built in 1849, and two years after they had been constructed they slid forward slightly due to a stack of coal having been deposited on the wharf, the walls failed in 1887 when they slid off the timber platform and overturned. The material behind the walls was a muddy sand weighing 113 lbs. per cub. ft., and when wet it had an angle of repose of from 16 to 20 degrees. The walls were built of squared stonework in lime mortar.

At Ramsey, in the Isle of Man, there was an old quay wall built about 1892, which failed after 30 years of safe existence; this wall was 25 ft. 6 in. high, 3 ft. 6 in. thick at the top, and 7 ft. 6 in. at the base, with a batter of 1 in 12 on the face, the toe being protected by timber sheet piling. Although this wall did not actually overturn, it slid forward taking a large convex curve, and cracking in several places throughout its length. As a general rule, wharf walls should be constructed with a thickness at the base equal to half the height, but the thickness of these walls which failed was from $\frac{1}{3\cdot3}$ to $\frac{1}{3\cdot5}$ of the height, their construction having apparently been based on an old rule for the thickness of retaining walls on dry land.

The sketches, Figs. 1 to 10, show various types of wharf walls that have been constructed successfully.

In Fig. 1 is shown the mass concrete gravity wall; this form of wall must be constructed inside a cofferdam or in a deep heavily-timbered trench, and in most cases, with the exception of a soil like London clay, constant pumping will be required to keep the trench dry.

It is an expensive type of wall, built of concrete lowered in skips from cranes, or deposited between the shuttering through a shoot or tremié reaching from the surface to the base of the wall.

The facework concrete, from 1 to 2 ft. thick, is usually in the proportion of 1-2-4, while that of the body of the wall is of weaker quality, say 1-2½-5½, large stones or "plums," from 1 to 8 cub. ft. in volume, may be deposited in the concrete masswork, with at least 1 ft. of concrete between them.

The excavation of the trench, the timbering, and the shuttering form large items in the cost of this wall, and for a wall 54 to 60 ft. high, and 28 ft. wide at the base, for 30 ft. of water at L.W. and 40 ft. at H.W. alongside, the cost of the trench would be about £33 per lin. ft., and of the timbering £40 per lin. ft., while the wall would cost £84, or a total of £157 per lin. ft.

The estimate does not include for dredging in front of the wall, nor for the filling at the back, as these depend upon local conditions.

Fig. 2 illustrates the blockwork wall, which is a form of wall suitable for construction in the water. A trench is first dredged on the line of the site of the wall; this is then filled with rubble stone deposited by grabs or by hopper barges; this is levelled by divers, and on top a layer of small stones and gravel, or concrete, is laid and levelled.

The concrete blocks forming the wall are constructed in timber forms or moulds on the shore near the site; the concrete is usually in the proportion of 1-2-4, and is allowed two months in which to set.

The blocks are then put in barges, towed to the site, and deposited by a floating crane, the weight of a block 9 ft. by 4 ft. 6 in. by 4 ft. 6 in. being about 11½ tons; they are adjusted in position by divers.

Each block has grooves in each direction on the upper surface and corresponding ridges on the under surface to key them together, and so far as possible they should be laid with headers and stretchers in alternate courses. The ridges and grooves are absolutely necessary, as block walls built without them have slid on their courses, and straight joints through courses should be avoided in the cross section of the wall. Sometimes grooves, either square, circular or diamond shaped

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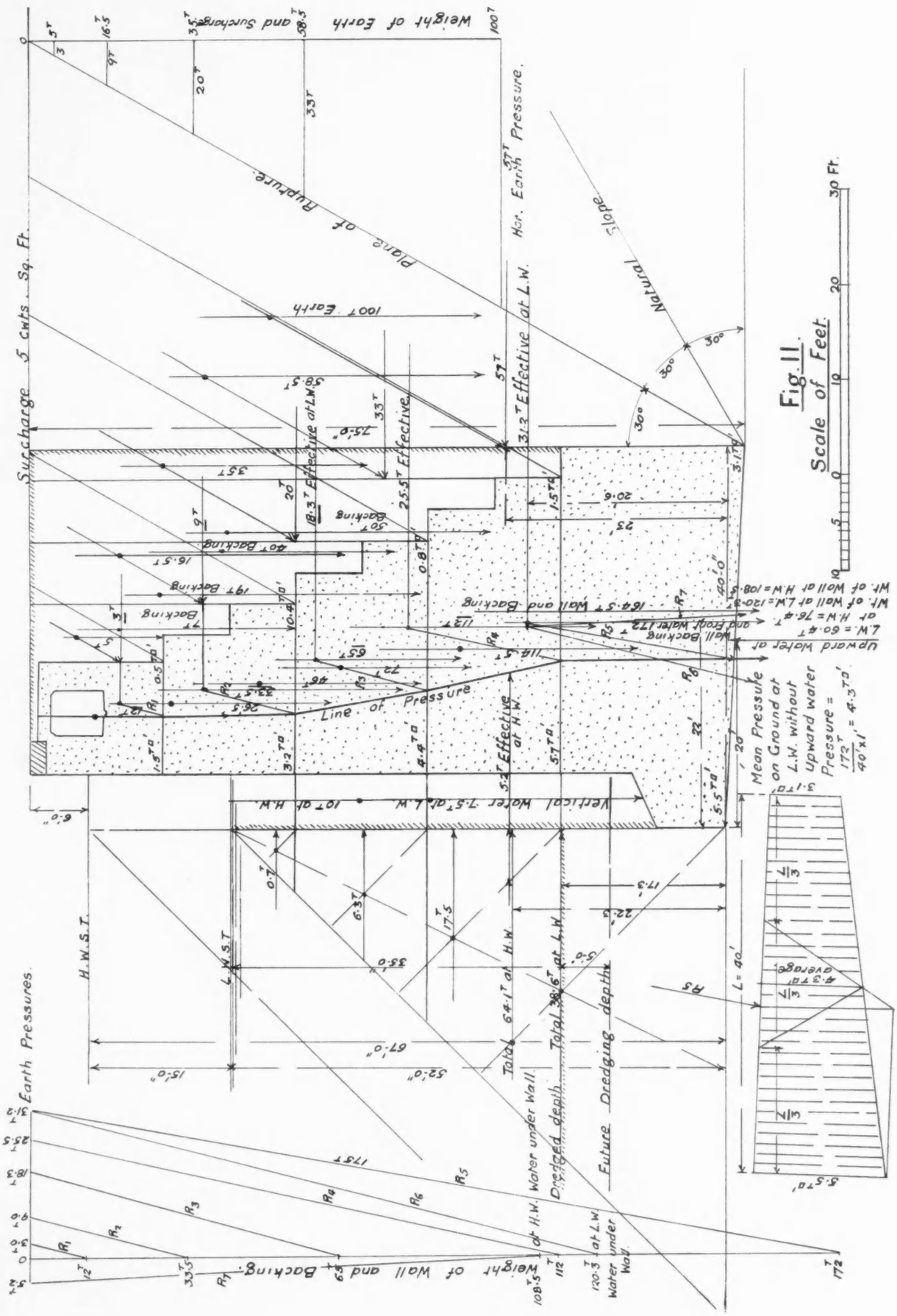
Weight of Earth and Surcharge
Plane of Rupture
Surcharge 5 cwts. Sq. Ft.
100T Earth
Hor. Earth Pressure.
Natural Slope
Effective at L.W.
Effective
Backing
Line of Pressure
Vertical Water 7.5T at L.W. 10T at H.W.
H.W.S.T.
L.W.S.T.
Total 38.6T at L.W.
Dredged depth
Future Dredging depth
Water under Wall
Earth Pressures.
Weight of Wall and Backing.
Wall Backing and Frost Water
Upward water at L.W. = 60.4T or H.W. = 76.4T
Wt. of Wall at L.W. = 120.3T
Wt. of Wall at H.W. = 108.5T
Mean Pressure on Ground at L.W. without upward water Pressure = 172T/40 x 1' = 4.3T a'
Average
Fig. 11.
Scale of Feet.
30 Ft.

Construction and Stability of Wharf Walls—continued

when the blocks are laid, are formed in the blocks, and the holes are plugged with canvas bags filled with 1 to 1 P.C. mortar.

The estimated cost of a wall of this type 46 ft. high, and 27 ft. thick at the base, for 30 ft. of water at L.W. and 40 ft. at H.W. alongside, would be about £130 per lin. ft., exclusive of filling at the back of the wall, and the proportionate cost of the block yard.

Fig. 3 shows a mass concrete wall in bad ground supported on timber or reinforced concrete piles. The estimated cost of a wall of this type, 50 ft. high and 25 ft. wide at the base for 30 ft. of water at L.W. and 40 ft. at H.W. alongside, is about £162 per lin. ft., including £27 for excavation and £30 for timbering, but exclusive of dredging and filling.

So long as timber piles are kept below bed level and placed so that the mollusc Teredo navalis, or crustaceans, Limnoria terebrans, and Chelura terebrans cannot easily reach them, they will last 50 or 60 years; the timber should be creosoted, and preferably of pitch pine, Oregon pine, oak or elm.

It was usual in the past to build walls of this form on timber platforms, 4 in. to 6 in. thick, laid on cross timbers spiked to the heads of the piles, but it is not advisable to do this, as the wall may easily slide off the platform under heavy lateral pressure due to water at the back of the wall, or to excessive loads on the wharf.

Fig. 4 illustrates an unusual type of wall: it is on Mr. F. Chaudy's system, and some of the old walls of Cork Harbour were successfully constructed thus.

At the back of the wall there is a continuous ledge or projection of concrete reinforced near the upper surface with old rails or iron rods at 12 inches pitch. It is a cheap form of wall, and the advantage of the ledge is that it supports the load of earth above and the surcharge on the wharf, also acting as a tie into the ground, and reduces the direct lateral earth pressure at the back of the wall, but it is important that the filling and backing to the wall should be well rammed and consolidated with water before the ledge is constructed, and there should also be reinforcement on the underside of the ledge, because if the wall should sink, there will be tension under the ledge.

Fig. 5 shows a monolith type of wall which has come into use universally in recent years, not because it is any cheaper than a mass concrete wall, but all trenchwork and heavy timbering is avoided, and provided that the sinking of the monoliths or bottomless caissons can be begun on land above H.W. level, no cofferdams are necessary.

On the site of the wall either steel or reinforced concrete shoes with a steel cutting edge are first constructed to a height of from 4 to 8 ft., and on these shoes concrete walls from 3 to 6 ft. thick are constructed inside steel or timber shuttering, leaving open cells between the walls, while the building of the walls is proceeding, excavation of the ground inside the cells is carried out by manual labour, assisted by grabs worked by overhead cranes. As the material is excavated below the cutting edge the monolith sinks, the rate of sinking being assisted by the weight of the side walls which are continually being built up, and by temporary cast iron weights or concrete blocks laid on the tops of the walls, or as a lining inside the cells, being carried on projecting ledges. When the monolith is sunk to the required depth, according to the nature of the ground, the lower portions of the cells are filled with 1-2-4 P.C. concrete, about 6 ft. thick; the remainder of the cells may then be filled with sand, gravel or weak concrete in the proportions of 1-2½-5½, the tops of the cells being plugged with 1 to 6 P.C. concrete from 4 to 6 ft. thick. The tops of the monoliths are usually above L.W. level, and the upper portion of the wall is formed of mass concrete inside shuttering. A space of from 4 to 6 ft. is left between each monolith; this is afterwards excavated and filled with concrete.

The cost of a wall of this type, 60 ft. high and 28 ft. thick, for a depth of 30 ft. at L.W. and 40 ft. at H.W. alongside, would be about £180 per lin. ft., exclusive of dredging and filling at the back.

The dimensions of monoliths vary considerably; for instance, at the Port of Tehuantepec in Mexico the monoliths were 59 ft. high, 42 ft. 7 in. long, and 19 ft. 8 in. wide, having 3 cells with walls 4 ft. thick; there were vertical grooves 1 ft. 6 in. by 1 ft. 6 in. in the end walls, filled with fine concrete to act as a key. The interiors of the cells were filled with sand, and with bottom and top plugs of concrete. There is 32.8 ft. of water alongside the wall at L.W. and 39.3 ft. at H.W. The thickness of this wall is only $\frac{1}{3.8}$ of its height, which is 65.76 ft.

Monoliths are usually made square in plan, varying from 30 to 40 ft., and in height from 60 to 80 ft.; the steel shoes, 5 ft. high, weigh about 65 lbs. per sq. ft. in plan, and they can be sunk in London clay at the rate of 3 ft. 6 in. per day, under favourable conditions, but as a general rule the rate is much slower, amounting to from 3 to 6 inches per day, and it is difficult to keep them in alignment.

Generally, these monolith walls can be sunk in the dry, but if much water is encountered, a steel or reinforced concrete covering at the top of the shoe can be constructed, with holes through it, from which two steel tubes or trunks are built to the ground level terminating in air locks, one for men, and the other for the excavated material, so that work can be carried on under air pressure. If there is a head of 35 ft. of water, the pressure will be 15.5 lbs. per sq. in., plus the atmospheric pressure of 14.7 lbs. per sq. in., a total of 30.2 lbs., to which must be added 20 per cent., bringing the total up to 36 lbs. per sq. in. to provide for "blows" or a sudden rush of air out under the shoe.

The friction of the ground on the outside of concrete monoliths varies according to the nature of the ground and the depth in the soil; in clay it averages from 5 to 8 cwts. per sq. ft.; in mud 3 cwts.; in sand from 5 to 6 cwts.; and in sand and silt from 3 to 4 cwts.

For brick wells sunk in India in alluvium it varies between 5 and 9 cwts. per sq. ft., and for stone wells between 3 and 12 cwts.

For concrete cylinders in mud and silt the friction amounts to from 3 to 12 cwts. per sq. ft.; for cast iron cylinders in sand and clay, it varies between 2 and 3½ cwts., and for steel cylinders in silty clay and mud, it is 2½ cwts.

Fig. 6. This type of wall is usually constructed in bad ground; it is carried on timber piles with sheet piling at the toe to resist any tendency of the wall to slide, and also to protect the toe from scour; with regard to this, it should be borne in mind that when steamships come alongside a wharf, deep holes are scoured in the bed of the dock or basin by the action of the propellers, and allowance should be made for this, for unless the toe of the wall is carried down well below the bottom level of the dock, there will be little resistance offered by the soil to the wall against slding.

To counteract any tendency of the wall to bulge or overturn, steel tie rods are fixed at intervals along the wall, near the top; these are connected to piles or concrete blocks buried in the ground of the wharf, beyond the point at which the line of rupture of the filling cuts the surface of the ground. The tie rods are usually covered with hessian saturated in tar, or with concrete, and should be supported on piles or posts at intervals to keep them straight.

Fig. 7 illustrates the reinforced concrete caisson type of wall; this form of wall is common on the Continent, such as at the Ports of Dantzic, Marseilles, Havre, Naples, Venice, Aalborg in Denmark, Gdynia in Poland, Kobe in Japan, Macassar, Sourabaya, Balawan, and Samarang in the Dutch East Indies.

It is a suitable construction for erection in water, but necessitates a convenient area for the construction of the caissons above tide level, also a slipway for launching them.

The cheapest and most convenient way is to utilise a small dry dock, if available, for the purpose of their construction, or a floating dock as was done at Rotterdam.

At Kobe, in Japan, the caissons were 117 ft. long, 24 ft. wide, and from 35 ft. 6 in. to 41 ft. 6 in. high, with a bottom 24 inches thick, and side walls 18 inches at the base, and 8 inches at the top. Each caisson had 20 cells, about 11 ft. square, the partition walls being 8 inches thick. These caissons were launched from a slipway.

At Aalborg, in Denmark, the caissons were 100 ft. by 10 ft. by about 30 ft. high, the base being widened to 20 ft. at the back, and supported by ribs to the caisson; the bottom of each caisson was 10 inches thick, the front wall 10 inches, and the back 6 inches. The caissons were built on a slipway, lying on one side, a temporary bulkhead was fixed to the top end, and they were launched horizontally in the water.

At Macassar the caissons were 81 ft. by 18 ft. 6 in. wide at the top, and 34 ft. 6 in. at the bottom, including the toes, and 37 ft. high, with two longitudinal partitions and cross ones; the front row of cells was filled with concrete and the back rows with gravel.

The caissons for the wet dock walls at Dantzic were 59 ft. 9 in. by 21 ft. 7 in. wide, and 34ft. 6 in. high; there were 5 cells in the length, and the bottom of each was 2 ft. thick, with 10-in. side walls and 8-in. partitions, through each of which was a large opening; the caissons were bedded on a levelled mound 2 ft. thick of rubble stone graduated from 6 in. in size downwards. They were fitted with a temporary bulkhead at the top, then tipped into the water, and towed to the site, where they were sunk by filling them with sand from a suction dredger. When in position, the outer wall of each caisson was increased to 4 ft. in thickness.

The caissons forming the wharf walls at Sourabaya, Balawan, and Samarang in the Dutch East Indies, are 43 ft. 6 in. high, and vary from 27 ft. 3 in. to 29 ft. 6 in. wide and long, with vertical walls 12 in. thick, and a central partition 4 in. to 6 in. thick, the bottom being 18 in. thick; they are filled with sand, and have a concrete plug at the top on which a mass concrete wall is built.

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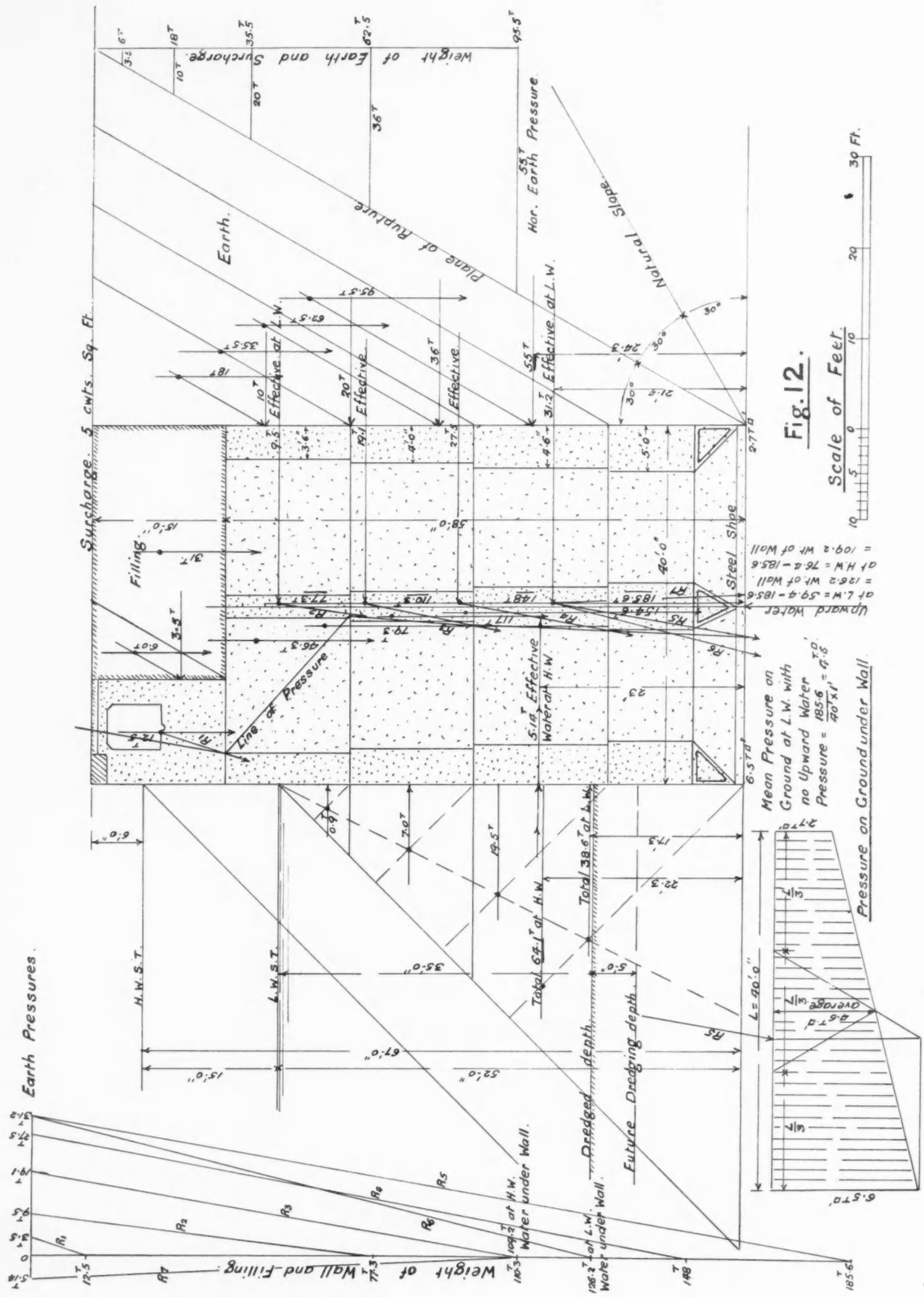

Fig. 12.

Scale of Feet

Construction and Stability of Wharf Walls—continued

The tops of caissons are usually arranged to stand above L.W. level, when sunk in position; the line of the wall is first dredged to the required depth, and the trench filled with rubble stone and gravel, levelled by divers; the caisson is then sunk, by filling it with sand, ballast or concrete as required, the latter being preferable for the front cells at least, as the walls are so thin; a concrete cap is deposited on the top of the cells, and the mass concrete wall to coping level is constructed on that.

A caisson of the type illustrated by Fig. 7, which is 100 ft. by 20 to 25 ft. wide and 35 ft. high, having 10 cells with 9 in. thick partition walls, bottom 2 ft. thick, and side walls 9 in. to 18 in. thick, would weight about 1,098 tons, and float at a draught of 16 ft.

The approximate cost of the complete wall for 30 ft. of water at L.W. and 40 ft. at H.W. alongside, would be about £106 per lin. ft., exclusive of filling at the back of the wall.

As regards the slipways for launching these caissons, these should have an inclination of $\frac{3}{4}$ in. per ft., or 1 in 16, and the timber groundways should be well greased, while the starting pull can be given by a tug-boat.

Fig. 8. This form of wall is much used in Denmark and Norway, and also at other ports. It consists of a concrete platform generally above L.W. level, carried on reinforced concrete piles, some of which are sloped or battered, and with tongued and grooved sheet piling in front of the wall.

Sometimes the platform is reinforced with steel rods, and on this the mass concrete wall is built inside shuttering.

The effective earth pressure on this type of wall is considerably reduced by the back projection of the concrete slab, so much so, that the pressures are usually reversed in direction, the effective water pressure on the front of the sheet piling being in excess of the earth pressure. This is an economical form of construction, but unless strong timber fender piles are driven in front of the sheet piles, there is danger of these being damaged by shipping.

The estimated cost of a wall of this type for a depth from coping to the bed of the basin of 46 ft., with 30 ft. at L.W. and 40 ft. at H.W. alongside, is about £93 per lin. ft., exclusive of dredging and filling at the back of the wall.

Fig. 9. This is a modification of the type of wall shown in Fig. 8, the mass concrete wall being carried direct on the piles, with either steel or reinforced concrete sheet piling at the back. In this case also strong timber fender piles are necessary, and the earth pressure at the back of the sheet piles may exceed the front water pressure, especially as sheet piling is not watertight, and the filling may be saturated with water, producing flat angles of repose and rupture, the lines taking concave curves, as is always the case when saturated earth or clay banks slide forward. It is preferable to use reinforced concrete sheet piles in lieu of steel, as the latter corrodes rapidly.

Fig. 10 shows a form of wall that is universally coming into use; it is constructed of reinforced concrete, with supporting triangular ribs at the back at intervals of 10 to 12 ft. The wall is carried on reinforced concrete piles, either battered or vertical or a combination of both, and on sheet piling in front, with timber fender piles.

The estimated cost of a wall of this type for a depth of 46 ft. from the coping to the basin bed, with 30 ft. of water at L.W. and 40 ft. at H.W. alongside, is about £60 per lin. ft., exclusive of dredging and filling.

With regard to the safe loads to be allowed on various soils, these vary so much according to the depth below surface, and the nature of the ground, that in most cases of important works it is advisable to make experiments with test loads, as clays, sands and gravels, or mixtures of these will stand considerable loads at, say, from 40 to 60 ft. below the surface, provided they cannot move laterally, but in the cases of wet dock walls and retaining walls generally, there is little resistance at the toes of the walls; consequently the pressures under the walls must be limited. For instance, in Fig. 11, the weight of the earth at the back of the wall amounts to 4.16 tons per sq. ft. on the ground at 75 ft. depth, while the pressures under the wall are 3.1 tons at the heel and 5.5 tons at the toe, and in front of the toe the weight of water at L.W., including 12 ft. of soil, only amounts to 1.8 tons per sq. ft.; consequently the loads at the back and under the wall are not balanced by the front loads, and there will be a tendency for the ground in front of the wall to rise in mound-like waves, causing the wall to subside at the back, and the toe to move forward; this has occurred in several instances.

A fairly safe rule for wet dock walls and retaining walls is for the load on the ground under the wall not to exceed $1\frac{1}{2}$ times the weight of the soil per sq. ft. from the coping to the base of the wall, although in pier foundations double the soil load could be safely put.

For ordinary foundations in London clay the safe load per sq. ft. should not exceed 4 to 6 tons; similar loads may be placed on sands and gravels, while alluvium and silt should be limited to from 2 to 4 tons, and most dry soils will safely carry from 1 to 2 tons per sq. ft. at or near the surface.

Under the piers of some Indian and Australian bridges, where the piers are carried down to a depth of over 100 ft. loads of 8, 9 and 10 tons per sq. ft. are imposed on the alluvium soil.

The weight of various soils when dry, and saturated with water, in lbs. per cub. ft., are as follows, viz.:—

Dry London clay, 122; saturated London clay, 141; dry boulder clay, 120; saturated boulder clay, 140; dry chalk, 102; saturated chalk, 127; compact dry earth, 90 to 94; damp earth, 105 to 110; saturated earth, 117; dry sea sand, 84 to 95; saturated sand, 126 to 131; dry silt, 72 to 78; saturated silt, 110 to 115; dry earth and stones, $1\frac{1}{2}$-in. size, 126; saturated earth and stones, 145; broken stones, $1\frac{1}{2}$-in. size, 106; dry gravel, 96; dry shingle, 89; rubble stone, 98-99; brick earth, 109; gravel up to 3 in. size, 104 to 105; mixture of dry sand, gravel and clay, 100; broken iron and antimony ores, 112; broken copper and tin ores, 109; broken Anthracite and bituminous coal, $1\frac{1}{2}$ in. to 2 in. size, 51; and granite road metalling, $1\frac{1}{2}$ in. to 2 in. size, 99 lbs.

The lateral pressure of liquid concrete against shuttering has been found to be 85 lbs. per sq. ft., wet concrete 75 lbs., and fairly dry concrete 70 lbs., while that of liquid mud weighing from 105 to 110 lbs. per cub. ft. is 30 lbs. per sq. ft.

With regard to the natural slopes or angles of repose to the horizontal of various soils, etc., the following are given:—Broken coal, 16° to 18°; mixture of sand, gravel and clay, 40°; damp sand, 52°; coarse sand, 33°-40°; fine sea sand, 33°-36°; dry earth, 46°; dry London clay, 45°; saturated London clay, 18° to 20°; dry boulder clay, 45°; saturated boulder clay, 16° to 18°, or even less according to the amount of saturation; stone rubble, 45°; compact earth, 50°; shingle, 39°; gravel, 40°; loose earth, 28°; dry river sand, 30°.

Railway cuttings are usually given slopes of $1\frac{1}{2}$ to 1 or 33°-42′, and banks, slopes of 2 to 1 or 26°-34′, and they usually stand safely at these slopes, except in clay, which is very treacherous when saturated with water, especially after hard frosts, and often cause considerable trouble by slipping to slopes of 3 to 1 or 18°-26′, and less.

In connection with the piles under walls, there are numerous formulæ for the safe loads on piles driven into the ground, but the results vary considerably, chiefly due to the factor of safety assumed, which ranges from 2 to 8. The formula for the static force of the blow of the ram, neglecting the time factor which is small, is $\frac{W \times H}{S}$ where W = weight of ram in tons, H = fall of ram in inches, and S = "Set" or depth driven in inches per blow of ram.

In the case of four timber piles, $14\frac{1}{2}$ inches square, driven from 42 to 45 ft. into soft alluvial soil by a ram weighing 2.5 tons, and fall of 42 inches, the final "set" was 1 inch per blow; the static force of each blow was therefore = $\frac{2.5 \times 42}{1}$ = 105 tons.

These piles when tested under a final load of 122 tons showed no appreciable settlement, and with a factor of safety of 2 should safely carry from 52 to 61 tons.

The friction in drawing one of these piles amounted to about 5 cwts. per sq. ft. of surface, while that of drawing timber piles out of sand and gravel amounts to from 9 to 10 cwts. per sq. ft., and of pulling concrete blocks vertically out of earth to from 7 to 9 cwts. per sq. ft. of side surface in contact with the earth.

Where piles project above the ground as in jetties and piers, the portions above the ground should be calculated as columns with fixed ends.

In Figs. 11, 12 and 13 the calculations for the strength of wharf walls of three different types are given. The earth pressures on these are based on the wedge theory, which in practice gives the safest results; the natural slope or angle of repose of the material is taken, and the angle made between that and the back of the wall is bisected; this gives the approximate angle of rupture, then the weight of the wedge between the line of rupture and the back of the wall, when resolved into its horizontal component, represents the actual pressure against the wall.

A length of 1 ft. of wall has been assumed in each case.

In Fig. 11 the weights of the various materials are as follows, viz.:—Sea water, 64 lbs. per cub. ft., or 35 cub. ft. per ton; concrete, 140 lbs. per cub. ft., or 16 cub. ft. per ton; and filling and backing, 124.4 lbs. per cub. ft., or 18 cub. ft. per ton.

Construction and Stability of Wharf Walls

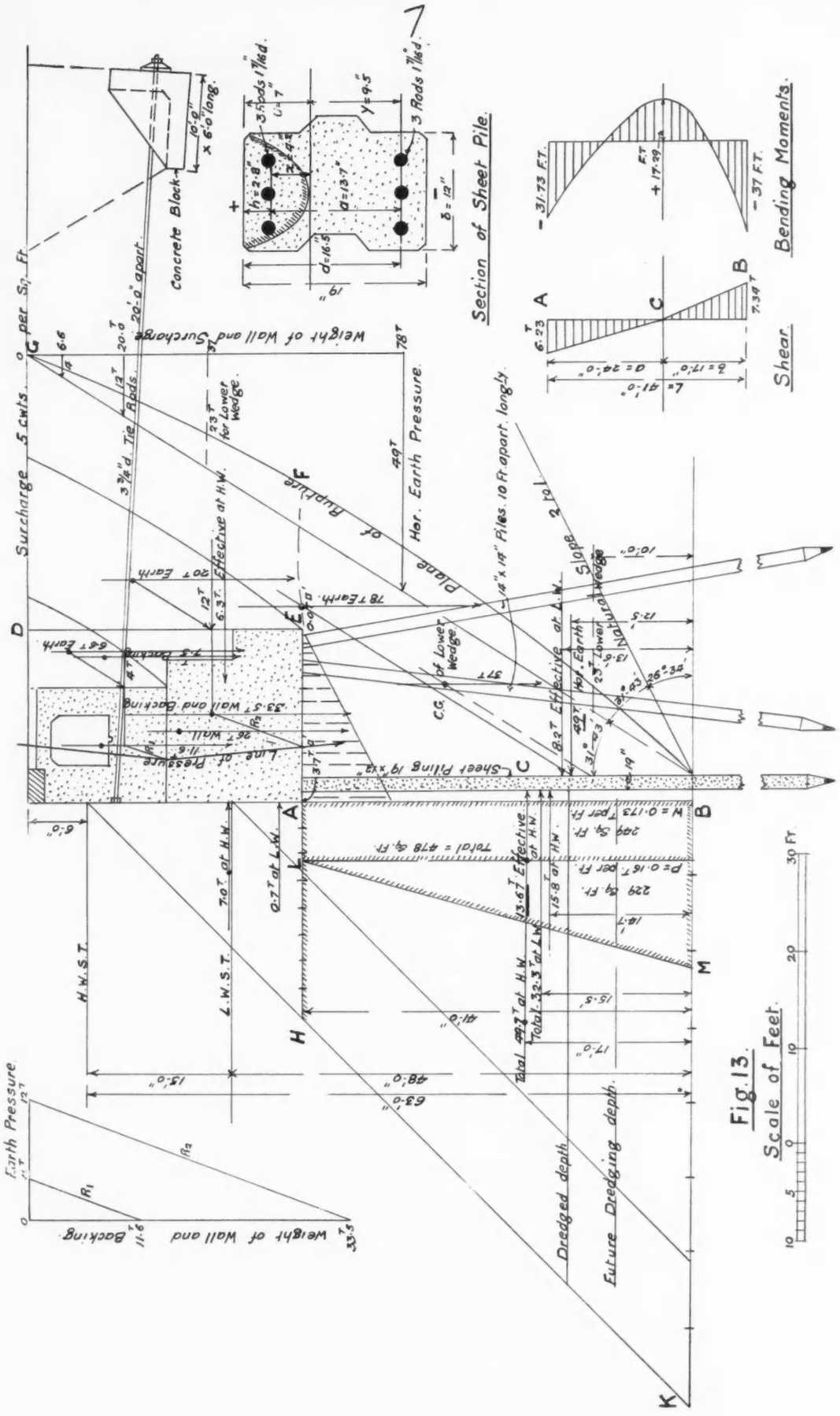

Fig. 13.

Construction and Stability of Wharf Walls—continued

The angle of repose of the earth at the back of the wall has been taken as 30°, and the angle of rupture at 60° to the horizontal.

The vertical weight of earth, to which has been added a surcharge of 5 cwts. per sq. ft. on the wharf, has been resolved into its horizontal component for each section of the wall at A, A+B, A+B+C, etc. The front water pressure at L.W.S.T. is taken to the base of the wall, as the water will creep to that level, the head being 52 ft., or equal to 38.6 tons. The vertical weight of the wedge of earth is 100 tons, including the surcharge, and the horizontal pressure is 57 tons, while the weight of the wall, including the backing, and the water on the toe, is 172 tons per lin. ft.

The effective earth pressure on the whole wall will be as follows, viz.:—

Moment of earth at toe = 57 × 23 ft. = 1,311 ft. tons.

Moment of water at toe = 38.6 × 17.3 ft. = 667.7 ft. tons.

A difference in favour of the earth of 643.3 ft. tons.

The height of the mean C.G. of the two pressures above the base will be = $\frac{1311 + 667.7}{57 + 38.6}$ = 20.6 ft., and $\frac{643.3}{20.6}$ = 31.2 tons, which is the effective earth pressure.

This is repeated for each section of the wall, and the remainder of the diagram is self explanatory.

If water pressure is assumed under the wall at L.W.S.T. there will be an upward pressure of 60.4 tons, and the moments of the water and of the wall will be:—

M. of wall from toe = 172 × 22 ft. = 3784 ft. tons.

M. of water from toe = 60.4 × 20 ft. = 1208 ft. tons.

A difference of 2576 ft. tons in favour of the wall

$\therefore x = \frac{4992}{232.4}$ = 21.4 ft. and $\frac{2576}{21.4}$ = 120.3 tons

effective weight of wall, resulting in a pressure of 5.5 tons per sq. ft. at the toe, and 3.1 tons at the heel.

If the wall is waterborne at H.W.S.T. under a head of 67 ft. the effective weight of the wall will be 108.5 tons, and the pressure on the toe will be 1.8 tons sq. ft., while that on the heel will be 3.6 tons sq. ft., as the moment of the water pressure is greater than that of the earth, resulting in an effective water pressure of 5.2 tons.

The factor of safety against overturning of the wall at L.W.S.T. will be:—

M. of wall = 172 × 22 ft. = 3784

$\frac{\text{M. of wall}}{\text{M. of earth}} = \frac{3784}{655.2} = 5.7$

M. of earth = 31.2 × 21 ft. = 655.2

and with the wall waterborne at L.W.S.T. it will be = 4.3.

The lateral force required to slide the wall at L.W.S.T. = 172 × 0.5 = 86 tons, if the ground is dry, but if the wall is waterborne it will be = 120.3 × 0.3 = 36 tons, and the actual lateral earth pressure is 31.2 tons.

Fig. 12 shows the pressure diagrams for a wall of the monolith type, the interior of the monolith being filled with weak P.C. concrete. In this case the weight of the wall is 185.6 tons per lin. ft., resulting in pressures of 6.5 and 2.7 tons per sq. ft. at the toe and heel respectively, with water pressure at L.W.S.T. in front, as representing the worst condition, so far as the load on the ground is concerned. Allowing for water under the wall at L.W.S.T., the upward water pressure will be 59.4 tons for 52 ft. head, and the effective weight of the wall will be 126.2 tons, resulting in pressures of 5.5 tons at the toe, and 0.7 ton at the heel.

The pressure required to cause the wall to slide will be 185.6 × 0.5 = 92.8 tons, and if waterborne at L.W. it will amount to 126.1 × 0.3 = 37.9 tons. At H.W. the water pressure will be greater than that of the earth, resulting in an effective water pressure of 5.14 tons.

If this type of wall is founded on good hard clay or gravel, it may not be necessary to carry the foundations down to any great depth in order to retain the water in a closed basin up to H.W. level, but if not, it will be necessary to have deep foundations.

Fig. 13 illustrates the sheet piled type of wall, with reinforced concrete interlocking sheet piles in front.

This form of wall depends for its stability on the resistance of the sheet piling to deflection, and it is advisable also to anchor the top of the wall by steel tie rods back to land piles or concrete blocks at intervals of 20 ft. or so in the length of the wall.

As sheet piling will not be watertight, it is probable that the ground at the back of the wall will be more or less saturated with water, and a natural slope of 2 to 1 or 26°-34′ has been assumed, also a concave curve to the line of rupture, the weight of the earth has been taken at 128 lbs. per cub. ft., or 17.5 cub. ft. per ton.

Some Continental engineers assume that the earth at the back of the wall from the base of the mass concrete portion to the surface represented by the wedge of earth D. E. F. G. in the diagram, has an arching action, and supports itself by friction against the wall and adjoining earth on the line of rupture. This does occur with damp earth, but not in the case of dry materials; for instance, dry sand and grain will readily run down a tube attached to a hopper, but will not if the materials are damp; consequently, in the case of a wall supporting damp earth, the pressure against the sheet piling will be due to the wedge of earth A. F. B. under the wall.

But other factors have got to be taken into consideration; there is the lubrication at the back of the wall due to surface water, disintegration of the earth by frost, the loads on the wharf, and vibration from railway and crane traffic, which all tend to cause the mass of earth at D. E. F. G. to move downwards, and compress the triangle of earth A. B. F. below.

The weight of the earth D. E. F. G. would be 35 tons per lin. ft., the friction areas D. E. and F. G. will be 60 sq. ft.; this will give a friction of 1,306 lbs. per sq. ft. necessary to sustain the earth, and as the actual friction of damp earth is about 77 lbs. per sq. ft., it would seem that such arching action can only take place temporarily, the upper wedge of damp earth acting as it would in a hopper. If the pressure on the sheet piling is only due to the lower wedge A. B. F., then at L.W. the moments will be:—

M. of earth = 23 × 10′ = 230.0 ft. tons.

M. of water = 32.2 × 15′.5 = 499.1 ft. tons, or 269.1 ft. tons in favour of the water.

The position of the mean C. G. will be = $\frac{729.1}{35.2}$ = 13.2 ft.

and $\frac{269.1}{13.2}$ = 20.3 tons effective water pressure.

At H.W. the moments will be:—

M. of earth = 23 × 10′ = 230 ft. tons.

M. of water = 49.7 × 17′ = 844.9 ft. tons, or 614.9 ft. tons in favour of the water.

The mean C. G. height = $\frac{1074.9}{72.7}$ = 14.7 and $\frac{614.9}{14.7}$ = 41.8 tons effective water pressure.

These are rather high pressures, and experience of the construction of wharf walls of this type has shown that comparatively thin sheet piling is capable of sustaining the pressures, so they must be less than is generally assumed.

The wall shown in Fig. 13 will therefore be calculated for the weight of the whole mass of earth D. E. A. B. F. G., which will give reduced effective pressures. The moments at L.W.S.T. will be as follows, viz.:—

M. of earth = 49 × 12.5′ = 612.5 ft. tons.

M. of water = 32.3 × 15.5′ = 500.6 ft. tons, or 111.9 ft. tons in favour of the earth.

The height of the mean C. G. will be = $\frac{1113.1}{81.3}$ = 13.6 ft.,

and $\frac{111.9}{13.6}$ = 8.2 tons effective earth pressure.

At H.W. the moments will be:—

M. of earth = 49 × 12.5′ = 612.5 ft. tons.

M. of water = 49.7 × 17′ = 844.9ft. tons, or 232.4 ft. tons in favour of the water.

The mean C. G. height = $\frac{1457.4}{98.7}$ = 14.7 ft., and $\frac{232.4}{14.7}$ = 15.8 tons effective water pressure, but as the C. G. of the water pressure acts at 17 ft. above the base, the effective pressure at this height will be 13.67 tons, which will give the same bending moment, and will be taken as the maximum load on the sheet piling, and as this load is distributed, increasing from A to B, divide the lines A H, and B K, into an equal number of parts. The volume per lin. ft. of wall for 13.67 tons = 13.67 × 35 = 478.45 cub. ft., therefore draw the line L. M. so that the area included in A. L. M. B. = 478 sq. ft. to the same scale as the diagram, the rectangular portion of this area will be = 249 sq. ft., equivalent to 7.11 tons per lin. ft., or 0.173 ton per depth of piling affected.

The triangular part will have an area of 229 sq. ft. = 6.55 tons, or 0.16 ton per depth of pile, = 41 ft.

The depth of 8 ft. below the bed, is assumed to be the point at which the piles are fixed; the tops of the piles are also assumed to be fixed.

The calculations for the strength of the sheet piling will be as follows, viz.:—

W = load per lin. ft. = 0.173 ton on rectangular portion of diagram.

P = load per lin. ft. = 0.160 ton on triangular portion of diagram.

L = length in ft. of loaded portion of piles = 41 ft.

Construction and Stability of Wharf Walls—continued

A = length from top of piles to C. G. of water pressure, and B = length from C. G. of water pressure to base line.

Then M at A $= L^2\left(\frac{W}{12}+\frac{P}{30}\right)=41^2\left(\frac{0.173}{12}+\frac{0.16}{30}\right)=31.78$ ft. tons

M. at B $= L^2\left(\frac{W}{12}+\frac{P}{20}\right)=41\left(\frac{0.173}{12}+\frac{0.16}{20}\right)=36.98$ ft. tons Say 37 ft. tons

M. at C $=\frac{W}{2}\left(A.L.-A^2-\frac{L^2}{6}\right)+\frac{P}{2}\left(\frac{3L.A.}{10}-\frac{A^2}{3L.}-\frac{L^2}{15}\right)$

$=\frac{0.173}{2}\left(24\times41-24^2-\frac{41^2}{6}\right)+$

$\frac{0.16}{2}\left(\frac{3\times41\times24}{10}-\frac{24^2}{3\times41}-\frac{41^2}{15}\right)=17.29$ ft. tons

The Shear at A $=\left(\frac{W}{2}+\frac{b\times P}{L}\right)L=\left(\frac{0.173}{2}+\frac{17\times0.16}{41}\right)\times41$

$=6.23$ tons

Shear at B $=\left(\frac{W}{2}+\frac{a\times P}{L}\right)L=\left(\frac{0.173}{2}+\frac{24\times0.16}{41}\right)\times41=7.34$ tons

The B. M. is 37 ft. tons, or 37 × 2240 × 12 = 994,460 inch lbs., and if the safe stress on the concrete = 700 lbs. per sq. inch with 9,000 lbs. on the steel in compression, and 16,000 lbs. on the steel in tension, the calculations for the strength of the sheet piling will be as follows: assuming a pile 12 in. wide and 19 ins. thick, having an effective thickness or depth of section = 16.5 inches = d, then z, which is the proportion which the position of the neutral axis from the compression side, bears to the depth of the section—

$$Z=\frac{M}{b.d^2\times700}=\frac{994560}{12\times16.5^2\times700}=0.43$$

$$\text{And } d=\sqrt{\frac{M}{Z.b.700}}$$

The distance from the compression side to the neutral axis = U = zd = 0.43 × 16.5″ = 7.09″, say 7″, and from the neutral axis to the centre of the tension steel = y = 9.5 inches.

From the compression side to the centre of the concrete in compression the distance h = 0.4 u = 0.4 × 7″ = 2.8 ins. The lever arm for the compression steel = x = 4.2 ins., and for the whole section = a = 13.7 ins.

The area of the tensile steel required will be:—

$\frac{M}{a\times16000}=\frac{994,560}{13.7\times16000}=4.5$ sq. ins. and 8 rods 1 7/16 in. diameter = 4.87 sq. ins.

As there is a slight excess of steel, the actual stresses will be, with a moment of inertia I = 10,000 inch units, and

$\frac{Es}{Ec}=\frac{30,000,000}{2,000,000}=15$

on the concrete $=\frac{M\times U}{I}=\frac{994,560\times7''}{10,000}=696$ lbs. per sq. in.

on the tension steel $=\frac{M\times Y\times15}{I}=\frac{994,560\times9.5''\times15}{10,000}=$ 14 172 lbs. per sq. in.

and on the compression steel $=\frac{M\times X\times15}{I}=\frac{994,560\times4.2''\times15}{10\,000}=$ 6.265 lbs. per sq. in.

As the vertical load on the sheet piles from the wall is 3.7 tons per sq. ft. at L.W.S.T. there will be a load of 5.84 tons per pile, or 57.3 lbs. per sq inch, which must be added to the compression on the concrete, bringing the total up to 753.3 lbs. per sq. inch, and as the ultimate compressive strength of the strong concrete, usually in the proportion of 1-1½-3 of which piles are made, ranges from 3,500 to 4,000 lbs. per sq. inch, there will still be a factor of safety of four.

With regard to the anchor tie rods spaced 20 ft. apart, the weight of the wall, etc., is 33.5 tons, which multiplied by 0.5 gives 16.75 tons as the lateral pressure that would push the wall, and the actual earth presure is 12 tons, neglecting the small amount of water pressure in front at L.W.S.T. If there is water under the wall at L.W. the upward pressure will be 3.6 tons, and the weight of the wall will be reduced to 29.9 tons, which multiplied by 0.3 = 8.97, or say, 9 tons the resistance of the wall, or lateral pressure required to push it, leaving 12-9 = 3 tons to be resisted by the piles and tie rods.

The effective earth pressure on the sheet piles is 8.2 tons; this will give an outward reaction at the top of the piles = 2.72 tons per ft. if this is allowed to be taken by the piles, then the 3 tons can be taken by the tie rods.

At H.W.S.T. the upward pressure under the wall amounts to 11.3 tons, which deducted from the weight of the wall, leaves 22.2 tons, and this multiplied by 0.3 gives 6.6 tons as the pressure that would move the wall, and the effective earth pressure = 6.3 tons, allowing for the water pressure in front of the wall, this is balanced by 6.23 tons reaction from the sheet piles.

Therefore 3 tons per ft. on the tie rods × 20 ft. = 60 tons, which is the tension to be taken by each tie rod, and allowing 6.5 tons per sq. in. safe tension, then 9.2 sq. ins. will be required. A steel rod 3½ ins. diameter = 9.62 sq. ins., allowing for threads, a rod 3¾ ins. diameter = 11.04 sq. ins. will meet the case.

The concrete block shown in the diagram will weigh 14.5 tons, and the earth on top 72.5 tons, a total of 87 tons, plus friction to resist the pull of 60 tons.

British Industries Fair, 1937

Castle Bromwich Section: Port of Bristol Authority, Stand No. Cb 901 and 800

The Port of Bristol's exhibit, situated at Stand Cb 901 and 800, maintains the high standard of former years. It commands attention by means of an artistic display in which is embodied a number of remarkably interesting features. Conspicuous among them is a large scale model of Avonmouth Docks, probably one of the finest models of its kind in the country. Supplementing this splendid example of the model-maker's art—which clearly depicts the modern construction and equipment of Bristol's ocean docks—is a central kiosk of an attractive pattern. A large and interesting collection of coloured photographic transparencies is displayed in a concave recess of this structure.

Having thus illustrated the facilities provided for the accommodation of all types of vessels and merchandise, the exhibit proceeds to demonstrate the port's wide area of distribution. This embraces not only Bristol's immediate hinterland, including the Western and South-Western Counties and South Wales, but takes in the Birmingham district, for which Bristol is the nearest ocean port. A large map in colour emphasises the central geographical position the Port of Bristol occupies in supplying the needs of these thickly-populated areas. A further arresting feature of a well-balanced exhibit is a map of the world, showing the overseas steamship connections of the port.

From a topographical standpoint, visitors will find much to interest them in a large scale ordnance map of the Port of Bristol's entire docks system, which shows the close relationship of the docks to the land still available for new industries. The Port Authority's strong claims for further industrial development are dealt with in an attractive brochure, which is available at the stand, together with other informative publications.

The Port of Bristol Authority has been represented at the Birmingham Section of the British Industries Fair for a great many years; indeed, Bristol may be numbered among its oldest and staunchest supporters. This progressive municipality believes in advertising its wares, and judging by the record tonnage in ships and goods which entered the port last year, the enterprise has been more than justified.

Waterford Port.

At a meeting of Waterford Harbour Commissioners, held on 12th January, Mr. Shipsey, Secretary and General Manager, stated that ships trading to the port during 1936 had increased by 114. Tonnage was greater by 37,000 tons. Dues were up almost £600. Over 6,000 extra cattle had been shipped, and there was a net total increase in revenue of £1,600 over the previous year. Twelve thousand extra tons of coal, 9,000 tons of wheat, 2,000 tons of basic slag, and 2,200 tons of cement were imported. Mr. Shipsey stated that while foreign ships using the port had decreased from 72 to 53, cross-Channel and coastwise vessels had increased from 419 and 523 to 439 and 640 respectively.

North-East Coast Notes

THE year 1937 started on the North-East Coast with bright prospects and a feeling of strong optimism. The shipyards were busy, the staiths were kept actively employed, coal prices were higher than they had been for a long time, freights were more remunerative than for many months past, and idle tonnage was reduced almost to a minimum. So far as the Tyne was concerned, there was disappointment at the coal and coke shipments, for 1936 were below the figure for the previous year. The total was 13,315,214 tons, a decrease of 36,165 tons on the figure for 1935, but it should be remembered that in 1935 the exports to Italy nearly touched a million tons, while last year the quantity had fallen to a paltry 60,000 tons. Blyth for the third year in succession created a record, the shipments from that port in round figures being 6,787,000, compared with 6,512,000 tons in 1935. Altogether it is estimated that last year the shipment from the Tyne, Wear, Blyth and Hartlepools totalled 26,011,200 tons, compared with 25,667,800 tons in the preceding year. A distinct advance on these quantities is anticipated in the present year with the renewal of trade with Italy and heavier exports to France.

North-East Coast Trade Review.

A most interesting review of trade prospects on the North-East Coast was given at the meeting in January of Newcastle and Gateshead Chamber of Commerce by Mr. Ridley Warham, senior vice-president. Iron, steel, coal and shipbuilding industries, he said, were all much improved. The national export of coal, however, including bunkers, in the eleven months ended November 30th, was down just upon five million tons on the previous year, the aggregate being just over 42,000,000 tons. Tyne shipments overseas and coastwise for the whole of last year were 36,000 tons down, but in the circumstances the decrease was not heavy, for it was due to the temporary loss of Italian trade. In 1934 the Tyne shipped 1,620,000 tons of coal to Italy, in 1935—955,000 tons, and in 1936 it had dropped to 60,000 tons. In view of these figures the Tyne's decrease was really very favourable. A friendly agreement having been entered into with Italy, it was hoped that trade with that country would improve. As regards France the coal import quota had been doubled for December, and it was hoped it would continue throughout this year, and that the North-East Coast would get a fair share of the trade. Trade with Scandinavia continued to improve, and hopes were bright for 1937. He referred to Blyth's record of shipments, and said that the quantity shipped in three successive years was in each case a record for the port. In 1936 the Blyth shipments were more than half of the shipments of the Tyne with all its shipping places. Although trade generally had so greatly improved it was very necessary in the national, as well as the local, interest to increase markets in foreign countries and to try to regain those that had been lost. He suggested that they should look ahead, and make provision for whatever difficulties might arise in the future.

New Customs Station.

At the December meeting of the Tyne Improvement Commission it was stated that the Secretary (Mr. A. Blacklock) had reported to the Harbour and Ferry Committee that the Collector of Customs, Newcastle, had had interviews with him in regard to the formation of a middle station on the Tyne for the better protection of the revenue. It had been proposed to base this station at a building close to the Willington Quay landing-place of the old Jarrow ferry, and sufficient progress had been made to allow of tenders being invited for the construction of a pontoon at which the Customs launches would moor. Before the pontoon was placed there, it was desired to have the sanction of the Commissioners. The matter was referred to the engineer and harbour-master for a joint report.

The tender of Messrs. Benjamin Peel, Ltd., Tynemouth, amounting to £2,751, was accepted for the erection of a new building to accommodate Messrs. Matthiesen and Co., local agents for the B. and N. Line, and also the Customs authorities and the Olsen Line at Albert Edward Dock.

At the same meeting of the Commission, the gratifying announcement was made that the idle tonnage in the river had been reduced to 16 vessels, the lowest figure for the past seven years. It was also stated that at the same time there were 34 vessels of 209,000 gross tons under construction on the river.

The Secretary reported that in regard to the fire which had occurred at the new Jarrow staiths, and which caused damage to such an extent as to preclude shipments from the staith at present, a claim had been made against the Commissioners' underwriters in respect of the damage and for services rendered. It was reported that instructions had been given to Messrs. Turnbull and Co., the contractors for that portion of the scheme which had been damaged, at once to proceed with the necessary re-instatement. Sanction was given for this course to be adopted. Meanwhile, Messrs. Bowes and Partners are using their old staiths for shipments.

Blyth and Wear.

Mr. R. M. Sutton, the Chairman of Blyth Harbour Commission, at the meeting in December, referring to the financial position of the Commission, said he was glad to be able to announce that in view of the steady trade of the port, that the Commissioners had found it possible to continue the allowance of 10 per cent. discount on all dues for a further period of six months from January 1st.

It is reported that the London and North-Eastern Railway Company have placed with Messrs. Fraser and Chalmers' Engineering Works, of Erith, Kent, a contract for an anti-coal breakage appliance for use at Blyth on the South side of the river. It is expected that the appliance will be in operation next March.

The official trade statement for the Wear up to the end of November showed welcome increases so far as exports are concerned. The coal and coke shipments for the period named totalled 3,672,421 tons, against 3,496,592 tons in 1935, an increase of 175,829 tons. Other exports totalled 46,711 tons, against 34,899 tons in 1935. The main increase was in machinery, which rose from 2,800 tons to 9,701 tons. Imports showed a decrease, the total being 299,475 tons, against 316,442 tons in 1935. Timber fell from 123,263 loads in 1935 to 93,168 loads in 1936; on the other hand, grain was doubled at 14,789 tons in 1936, against 7,377 tons in 1935, and iron and steel increased from 666 tons in 1935 to 3,281 tons in 1936.

Hartlepools and Tees.

The trade returns for the Hartlepools for the past year are of a mixed character, for while the coal shipments are 8.52 per cent. lower, timber imports are 4.31 per cent. higher. The coal and coke exports for 1936 were 3,143,074 tons, against 3,435,802 tons in 1935. Timber imports were 19,358 loads up at 467,603, against 448,245 loads in 1935.

The statistics regarding the iron and steel industries on the Tees are instructive, for while the imports of iron ore at a little more than two million tons were the highest for many years, yet the shipments of iron and steel from the river fell from 577,000 tons in 1935 to 526,397 tons in 1936. This was a sequel to the increased activity in those industries at home, which left less material for export.

How Canada Protects Shipping.

With approximately 50,000 miles of coast line along the Atlantic and Pacific Oceans, the Great Lakes and other lakes within the boundaries of the Dominion, the Canadian Government Department of Marine consequently has to maintain an extensive lighthouse service. This service requires, during the season of navigation, 2,000 lights, 400 fog signals, 600 gas and signal buoys, 12 lightships, 32 radio stations, 9,000 unlighted buoys, beacons and day marks, a total of more than 12,000 individual establishments.

One of the best-known lighthouses, to those who go down to the sea in ships, which comes under the administration of the Canadian Government Department of Marine, is the lighthouse at Cape Race, on the coast of Newfoundland. The flashing light in this lighthouse is over one million candle power, and has been seen a distance of 76 miles. The optical apparatus and lantern weigh 42 tons, and cost $40,000.

The source of light is electricity generated on the premises, and the fog signal, which has been heard 45 miles away, is operated by compressed air. Four hundred tons of coal are required to generate the necessary electricity. Four lightkeepers maintain continuous watch day and night throughout the year at the Cape Race lighthouse. Thirteen lighthouses are maintained on the coasts of Newfoundland and Newfoundland-Labrador by the Canadian Government to aid trans-Atlantic shipping to and from the shores of Canada.

If it were not for the protective service which Canada provides on Sable Island, 118 miles south-east of Halifax, Nova Scotia, familiarly known as "The Graveyard of the Atlantic," the toll of disasters would be very much greater. In addition to two first-class lighthouses, watch-towers and life-saving stations are maintained there at strategic points. In clear weather the entire coast line is under observation from the lighthouses and watch-towers. In fog or thick weather mounted men patrol every mile of the island, which is 18 miles long and consists wholly of sand in places 100 feet high. Sand bars extend several miles from each end of the island.

Over 2,000 persons are employed in the lighthouse service of Canada, who know by experience that the price of safety for shipping is eternal vigilance.

News from all Quarters

Belgium

IN spite of the dock strike in June, the figures of shipping entering the Port of Antwerp in 1936 show a notable improvement over the results of the previous year, for 11,429 ships with 22,942,526 n.r.t. entered, compared with 11,125 vessels with 22,035,257 n.r.t. The chief flags represented were Germany (6,043,111 n.r.t.), Great Britain (5,287,706), France (2,074,103), Norway (1,654,457), and Holland (1,396,152). The tendency for British tonnage to decline, while that of Germany increases is further continued, and the preponderance of tonnage which belonged to the British flag before 1935 seems to have passed definitely to Germany. The volume of imports carried in British ships, however, is still greatest.

The increased activity in the port, and the favourable prospects for 1937 have made the consideration of improved harbour facilities an urgent matter. Two new loading bridges, each of 15 tons capacity, have been ordered in addition to the two cranes that have now been installed, and it is intended to place contracts for four electric cranes and two floating cranes during the current year. The possibility of building a new warehouse near the quays is also being considered. The authorities realise, too, that if traffic continues to grow at its present rate, it will be necessary to construct a new dock. At the present moment the Kruisshans lock, which gives access to the new basin, is inadequate for the traffic, and plans for port development are being considered. The only consideration which troubles the port authorities is the possibility of further strikes. The seven-and-a-half hour working day is in force from January 25th, but the dockers are now demanding a seven-hour day. This would involve an important increase in lading costs, and might, it is feared, prejudice the expected improvement in traffic.

Other Belgium ports show an increased activity, traffic entering Ghent amounting to 2,172,538 n.r.t., compared with 1,928,188 in 1935, while Zeebrugge registered 2,077,251 n.r.t. instead of 1,728,972.

Holland

Activity in the Port of Rotterdam for the month of December showed great improvement on the figures for 1935, for 791 laden vessels entered the port, compared with 720 the previous year, and 701 left with cargo, compared with 630. This means that Rotterdam has been securing a greater share of the traffic than Hamburg and Antwerp, though both these ports are handling more business than formerly. Of the cargo handled, Rotterdam's share was 34.26 per cent. instead of the 32.31 per cent. of December, 1935. The figure for Antwerp has declined from 32.85 per cent. to 30.1 per cent., and for Hamburg from 30.23 per cent. to 28.74 per cent. The figure for Antwerp is, of course, affected by the dock strike, but nevertheless there is a clear tendency for Rotterdam to grow more rapidly than the other ports; German currency and import restrictions obviously handicap her ports, but the preference for Rotterdam over Antwerp is probably due to better facilities for unloading and distributing.

Amsterdam, too, shows an increasing volume of traffic, the figures for December being 279 ships entering with 1,860,000 n.r.t., compared with 244 vessels of 1,620,000 n.r.t. in the previous year. For the whole year the tonnage entering the port amounted to 20,290,000, compared with the 19,810,000 n.r.t. of 1935.

France

Shipping returns for the Port of Marseilles for the first eleven months of 1936 show a decline both in tonnage entered and cleared, compared with the corresponding period in the previous year. Clearances amounted to 13,877,587 n.r.t. instead of 14,117,218, and only 13,953,490 n.r.t. entered the port, compared with 14,107,374 in 1935. After French vessels (525,732 n.r.t. cleared) the flags clearing the most tonnage were British (280,812), Italian (129,637), and Dutch (60,176). Traffic is expected to improve in 1937, for last year the total volume of goods handled (5,492,976 tons) was greater than the 1935 figure. Moreover, the new regular monthly shipping service to Odessa via Athens, Istanbul and Constanza, which it is hoped to establish should increase the traffic handled.

Poland

Figures for cargo handled in the Ports of Gdynia and Dantzig show an increase of 6.3 per cent. over last year's total. The figure for Dantzig has increased by 10.3 per cent., and that for Gdynia by only 3.5 per cent., but that does not show the volume of the traffic. There is an increasing tendency for valuable merchandise to use the Port of Gdynia; there, time is saved by an immediate transfer to the railway. Bulky and less valuable goods make use of water transport, and are usually transhipped at Dantzig. Polish national sentiment, however, accounts for the rapid development of Gdynia; molasses, for instance, are frequently sent by water through Dantzig, and the barges towed across the bay to Gdynia twenty-five kilometres away. Bad weather, of course, prevents this passage, and assures the older port a certain share of this traffic. The present position of the two ports can be seen from the fact that 1,300,000 tons were imported and 6,400,000 exported through Gdynia, whilst Dantzig handled only 1,000,000 tons of imports and 4,700,000 tons of exports. The increasing importance of these harbours is evident, since they are now recognised by the North Atlantic Freight Conference as basic ports for calculating rates to Central America.

Egypt

The Suez Canal dues are to be reduced by 13 per cent. from April 1st. The reason for this step is the devaluation of the franc. In the first nine months of 1936 receipts were eighteen million francs below the corresponding figure for last year, but since the devaluation the situation has been completely changed. Receipts for the latter half of 1936 amounted to 840 million francs, compared with 816 million for the same period in 1935. The reduction of dues is expected to attract traffic to the Mediterranean route. The outlook for the Canal Company has been rather serious during the depression; the volume of seaborne traffic was declining, and shipping bound for the East tended to take the Cape route. The figures for the latter half of 1936 show a decline in ships using the canal, though devaluation had increased receipts. The new reduction which is now financially possible, will, it is hoped, do much to relieve this situation.

Denmark

Shipping entering the Port of Copenhagen in December amounted to 1,711 vessels with a total of 627,000 n.r.t. Of this, 445 n.r.t. was ocean traffic. The chief flags represented were the Danish (352,000 n.r.t.), Swedish (70,000 n.r.t.), Norwegian (36,000 n.r.t.), Polish (33,000 n.r.t.), and German (28,000 n.r.t.). Tourist traffic plays an important part in the activity of the port, and this occurs predominantly in the summer months, which accounts for the lower traffic in December.

Sweden

Port traffic at Gothenburg has increased spectacularly in 1936, and the authorities are preparing plans for a large expansion scheme. It is expected that tenders will be invited in the first quarter of the current year. Shipping entering the port during 1936 amounted to 5,168 vessels instead of 4,945, and a total of 3,135,217 tons of freight was discharged, compared with 2,788,602 tons in 1935. Stockholm, too, has experienced favourable shipping returns, and certain harbour extensions are contemplated. Meanwhile, the existing facilities are being improved by the installation of four new cranes.

Norway

Norwegian ports, too, are sharing in the general increase in shipping activity, and Oslo is installing seventeen new cranes, while other improvements are also scheduled for completion before the end of the current year. An interesting development in Norwegian harbour traffic is the increasing importance of Narvik. This is, of course, the port of shipment for Swedish ores, but the export trade in fish is growing rapidly. At present it is seriously hampered by inadequate refrigeration plant, and it is expected that considerable port development will take place in the near future to equip it for this traffic.

Jugoslavia

In 1934 Sussak was made a free port. Since then import traffic has grown to a surprising extent. For comparable periods it amounted to 619,518 quintals in 1935, and 1,137,757 quintals in 1936. It consisted essentially of goods which were not formerly imported through the Adriatic, especially coal, iron, machinery and phosphates. The Government intends to foster the development of the Adriatic ports as much as possible, and has accordingly fixed favourable railway freight rates for traffic going through them. The recently concluded commercial treaty with France will increase the Adriatic traffic, for wheat which was formerly shipped down the Danube, will go through Sussak to Marseilles. The total traffic through Sussak last year was unfavourably affected by sanctions, and was 52,000 tons below the 1935 figure of 566,313 tons. This, nevertheless, shows that the loss of trade with Italy was very largely outweighed by gains in other directions.

The Maintenance of Waterways to Docks and Harbours

(continued from page 86)

The biblical reference in Ecclesiastes, chapter XII, in the words " or ever the silver cord be loosed or the golden bowl be broken at the fountain, or the wheel broken at the cistern," is evidently to this Persian " chain of pots." The silver cord is the palm fibre cord bleached white by the sun and glistening with minute globules of attached water; the golden bowl, the earthenware pots, golden in colour; and the wheel, the top terminal wheel, the breaking of which or the loosening of the cord causing it to slip off the wheel, would result in the dropping to the bottom of the well of the whole chain of pots.

A similar device was used for irrigating the " hanging gardens " of Semiramis, in Persia, where water was lifted through a height of 300 feet. It is still used under the name of *Sakia* in Egypt, a notable example being the raising of water from Joseph's well in Cairo, 156 feet deep. Modifications of this chain of pots, still operated by man-power but with the introduction of gear-wheels to give increased efficiency, were mentioned by historians between 1550 and 1600, and were used for the drainage of mines and for dealing with excavated solid materials. In Great Britain, prior to 1600, such machines were constructed with wood or leather barrels attached to endless long-link iron chains, and were known as " bucket gins " or " scotch gins." A modification of the chain of pots was the Chinese " chain " pump mentioned in Chinese literature in A.D. 1145, in which the earthenware pots were replaced by flat square pieces of wood.

These various devices were undoubtedly the progenitors, not only of the bucket dredger, but of all land conveyors and elevators, and the earliest adaptations of them were made by the Dutch for the removal, *circa* 1685, of silt from harbours and docks. A dredger, based on the Dutch " Chinese " pump model, was in use at Hull Docks in 1785.

In the year 1750, during the demolition of Blackfriars Bridge, water was raised from the foundation caissons by means of Chinese pumps. It may be of interest to know that a very modern and efficient French pump is based on this model, but consists of an endless spiral rotated at speed, the spiral performing the dual function of chain and buckets.

The first steam ladder-dredger used in this country was Sir Samuel Bentham's model made in 1800. The primitive *Shadoof* used in Egypt for many years, and still used for lifting water in buckets from the River Nile, has developed into the steam navvy and the dipper dredger which, in its most advanced form, is in use on the Panama Canal for dealing with landslides in the Culebra Cut, where enormous quantities of debris and rock boulders up to 50 tons in weight are stated to have been removed by the buckets of the " dipper."

The *Shadoof*, a modification of which was largely used during the War for timber-loading, consists of an upright fixed pole carrying a horizontal arm capable of vertical and horizontal pivoting-movements. One end of the movable arm carries the bucket, the other end being elevated and depressed by man-power to fill and lift the bucket. Such machines were used in early days by the Dutch and Italians in dredging canals. An early adaptation in Great Britain was John Grimshaw's " spoon " dredger, built in 1796, and operated by a Boulton and Watt bell-crank engine of 4 h.p. Dredgers of this type were used in Portsmouth dockyard between the years 1802 and 1806. Grimshaw's machine lifted 2 tons of soil per minute at a cost of from 1d. to 2d. per ton.

What may be described as the introduction of sluicing was carried out by the Venetians in the 14th century for the removal of bars or deposits of silt in harbours, when on ebb tides, these were stirred and scraped with iron harrows attached to long wooden handles, which were operated by men in small boats. The ebb tide then carried the loosened sand into deep water. This method was also employed many years ago at Great Grimsby and on the Humber. A somewhat similar arrangement is in use to-day in the Great Western Railway Company's dock at Bridgwater. Here an iron drag or scoop at the end of a long pole is attached to the stern of a vessel by which it is dragged towards the mouths of sluices fixed in the dock bottom. Shortly before low water these sluices are opened, and water from the dock rushes through the sluices and a system of culverts under the dock bottom, carrying with it the accumulated mud into the river, whence it is borne away by the ebbing tide.

To sluice an entrance-channel to a dock, sluice-gates, provided in the walls of the lock or in the lock-gates themselves, are opened at or slightly before the time of low water. The outpouring mass of water sluices or swills any accumulated silted matter away from the dock entrance. The sluices in the gates give a more direct flow of water than those in the walls, where the discharges on either side of the lock may interfere with each other, and so reduce the force of the flow of water. In few, if in any, cases does sluicing carry silt sufficiently far for it to be carried away by the main tidal currents, but it does at least prevent accumulation at the dock-entrance, and to this extent reduces removal costs, in that it conveys the silt to a site whence it can be removed by bucket dredgers which cannot work in the vicinity of dock-gates owing to the restricted area of operation. Sluicing is, however, comparatively useless unless the depths of water over the dock sills at low water and the distance between the banks of the entrance channel are small. Thus no effective sluicing can be carried out at either Barry deep-water lock or Swansea, where sill cover never falls below 10 feet; but at the other South Wales ports, where such depths vary from 5 feet to nil, sluicing can be effectively carried out.

At Port Talbot, with a navigable channel width of 180 feet, and where strong west and south-west winds tend to pile up an accumulation of sand in the outer reaches of the channel, sluicing has proved of great value. Here, at a suitable tide, two steam hoppers are grounded in such a manner as to reduce the width immediately above the accumulation, that is to say, nearer the lock entrance. At low water the impounded dock water, with a head of some 20 feet, is released through the gate sluices and, after passing through the 40-foot channel between the hoppers, removes the accumulation of silt seawards. This operation is repeated over successive tides and is of particular value at Port Talbot where the range of swell is often too great for a bucket dredger to hold to its moorings.

It should be pointed out that the operation of sluicing, owing to the rapid discharge within a short period of time of large volumes of water, may occasion extensive erosion of the bed of the channel immediately in front of the dock-entrance apron, and thus undermine and otherwise damage the latter. To reduce this erosive action the apron should be so designed that the discharge of sluicing water at the lip should take place at an angle inclined slightly above the horizontal. The lowering of dock water-level due to the discharge of sluicing water must be balanced by pumping in channel-water. Should this be highly charged with solid matter, as is often the case, additional dredging-costs are incurred in the removal of this solid matter after settlement within the dock-gates.

At Newport the waters of the River Usk carry in suspension approximately 35 cubic yards of solid matter per 1,000,000 gallons. Such highly-charged water occasions heavy maintenance-expenditure on the wearing portions of the impounding pumps and, if economically possible, its use should be avoided by the provision of an alternative feeder-supply from which, when necessary, excess of solid matter has been removed by deposition before reaching the pumps.

Types of Dredging Craft

Modern dredgers are of four types: (1) sand-pumps and drag-suctions; (2) bucket or ladder; (3) dipper or spoon; and (4) grab.

The main difference between the types is that types (1) and (2) are continuous in action, either by the suction action of pumps or by elevation in buckets on an endless driver belt, whilst types (3) and (4) are intermittent.

Sand-Pumps and Drag-Suction Dredgers.

A typical example of the sand-pump is the one owned by the Mersey Docks and Harbour Board, which is capable of dealing with some 120,000 cubic yards a day of 10 hours, working in a depth of 70 feet. The drag-suction dredger is a development of the sand-pump and carries a special nozzle provided with rotary cutters and hydraulic jets for dealing with hard clay and soft rock. These dredgers have the advantage over the sand-pump type in that the dredged material is delivered into the hoppers with a minimum admixture of water. Typical examples of this type of dredger are those used in connection with the construction of the Buenos Aires Harbour, each capable of dealing with 10,000 cubic yards of clay in 12 hours. Many of the dredgers of these two types are provided with pumps to enable them to discharge the dredged material ashore for reclamation purposes.

No records exist of extensive trials of sand-pumps in the Great Western Company's Channel ports other than at Port Talbot, where the results were not altogether satisfactory. On p. 105 of a Paper by Mr. William Cleaver [1] a description is given of a 20-inch sand-suction plant, fitted with a specially-shaped nozzle and operated from the existing bucket dredger. This worked efficiently for some time, but after the adoption of the expedient of grounding craft to guide and increase the sluicing current, the channel is now almost entirely maintained by sluicing, and the use of the suction plant was discontinued.

[1] "Alterations and Improvements of the Port Talbot Docks and Railways during the last Decade." Minutes of Proceedings Inst. C.E., vol. cxci (1912-13, Part I), p. 103.

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The extension by Mr. William Cleaver of a short timber training-pier on the north side of the entrance channel by a tipped embankment of copper slag had an immediate and marked effect in reducing the rate of deposition of silt. Previous to this, silting often occurred to the extent of 5 to 6 feet in a few days, whereas later the same depth of deposit was hardly found in as many months. The embankment also served to check the travel of wind-blown sand from the adjoining beach.

At a later date, a sand-pump brought from Fishguard was fitted with a rotary cutter and a nozzle similarly shaped to that used by Mr. Cleaver, but for the reason given above was not kept long at work. With this exception no records exist of extensive trials of sand-pumps in the Great Western Company's Channel ports. Such trials, including those with the more efficient drag-suction dredgers, were not carried out as it was not anticipated that they would result in any improvement in economic working.

Bucket and Ladder Dredgers.

Dredgers which excavate and elevate material by means of an endless belt provided with steel buckets may be sub-divided into four classes:—

(a) Self-filling and self-propelled.
(b) Non-self-filling and self-propelled.
(c) Non-self-filling but dumb (incapable of self-propulsion).
(d) Self-filling but dumb (incapable of self-propulsion).

The selection of one or other of these classes, where bucket dredgers are used, must depend on local circumstances. In very narrow channels, where the presence of hopper barges alongside the dredgers would be detrimental to navigation, the self-contained carrier dredger is the only possible craft. It cannot, however, be described as economical, as during the whole of the time the craft is proceeding to and from the depositing-grounds, its main lifting engines are idle, so that its use should, if possible, be avoided.

Of the non-self-filling type, the provision of propelling engines is governed by how much shelter from bad weather exists in the channels to be dredged, and also by traffic conditions. Under the conditions prevailing in the Bristol Channel ports five bucket dredgers are used in conjunction with steam hopper-barges. Of these dredgers two are self-propelling and three non-self-propelling, one of the latter being a vessel used by the former Cardiff Railway Company.

On purely economic grounds the case for the dumb dredger is strong, the additional running and overhead costs consequent upon the provision of an independent set of engines for propulsion amounting to some 15 per cent. This can, however, be reduced to about 10 per cent. by the provision of a belt drive to the top tumbler of the dredging ladder, which, as well as the propellers, can then be operated by one set of engines. Dumb dredgers have the disadvantage of their dependence on other craft for mobility, but no general principles can be laid down to assist in assessing the practical value of this mobility beyond indicating that, in channels of sufficient width to permit of the use of barges but where interference with traffic must be reduced to a minimum, and particularly where in times of storm dredging craft must move quickly to sheltered ground, advantage will be gained by the use of self-propelled craft.

Whether or not a bucket dredger should be provided with a hopper is largely a matter of opinion, but a hopper is certainly useful in collecting droppings from the buckets. In 1931, the "David Davies," one of the Great Western Company's dredgers, collected and deposited 5,400 cubic yards, the average for the five years 1930-34 being 4,000 cubic yards. The space occupied by a hopper would otherwise serve no useful purpose, but its provision results in a higher freeboard, and so a longer working time for the attendant hopper barges.

Dipper or Spoon Dredgers.

Dipper dredgers follow the familiar lines of the steam navvy, and need no further explanation. They are largely used in excavating metalliferous deposits from the beds of rivers in Burma and elsewhere. The greatest development of this type of dredger took place for dealing with the enormous "slides" which occurred in the Culebra Cut soon after the opening of the Panama Canal. The dredgers were provided with 10- and 16-cubic-yard dipper buckets capable not only of lifting lumps of rock some 50 tons in weight, but of actually digging to a depth of about 50 feet in soft unblasted rock—shale and sandstone—at the rate of from 7,000 to 10,000 tons per 24 hours, according to the hardness of the material encountered. The yearly output on the Canal of three of these craft was approximately 10,000,000 cubic yards.

Grab Dredgers.

Grab dredgers, mounting one or more cranes, are indispensable for use in docks for dredging coal-tip berths alongside quay-walls and in other situations where a bucket dredger cannot conveniently work, and are largely so used in the Great Western Railway Company's ports. To reduce interference with dock traffic to a minimum, craft for this purpose should be self-propelled carriers, supplemented, where necessary, by large-capacity steam hoppers to reduce time lost in locking when proceeding to and from the depositing-grounds.

Although craft of this type more commonly deal with comparatively small quantities of material, an extremely useful general-purpose type is one mounting four grabs and of a hopper-capacity of 1,000 cubic yards. Grab dredgers so arranged have given excellent results on many large docks, and their use might with advantage be developed. The "Finn Mac Cool" operating at Buffalo, U.S.A., may be instanced as a typical example of a grab of large bucket-capacity. This craft has a 10-cubic-yard bucket operated by pneumatic power, with an output of 600 cubic yards per hour working in a depth of 65 feet.

Docks Organisation (Engineering)

The Great Western Railway Company's South Wales ports are divided into two groups—the eastern: Newport, Cardiff, Penarth, and Barry, and the western: Port Talbot and Swansea. At Barry and Swansea Docks a Divisional Engineer is stationed responsible for all the civil engineering work of the harbours in these respective groups other than dredging, which is in the charge of a Dredging Assistant to the Chief Engineer, with a staff of Dredging Inspectors.

The Great Western Company also owns the harbours and docks at Briton Ferry, Burry Port, Llanelly, Bridgwater, Plymouth and Fishguard. These are in the charge of the Railway Divisional Engineers, and dredging is carried out at them by units detached from the main fleet and controlled by the Dredging Assistant. At Brentford and Chelsea, where the conditions are special, seasonal dredging work is carried out by contract. Dredging at the western ports is mainly carried out during the summer months owing to weather conditions, but at the eastern ports there is little interruption from this cause.

Statistics of Dock- and Channel-Dredging

To indicate the extent of dredging essential to maintain the navigable waterways of the Great Western Railway Company, the largest private dock-owning corporation in the world, the following statistics of dock- and channel-dredging, covering all their ports, are given:—

	Year 1935: tons	Yearly average 1926—1935: tons
Docks	769,542	1,038,617
Channels	4,661,013	4,111,703
	5,430,555	5,150,320

This represents an expenditure of a capital sum for dredging plant of nearly £500,000, with an average yearly cost for the 10 years ended 1935 of some £60,000 for operation, including ordinary running repairs. Approximately £45,000 of this sum represents the corresponding costs in respect of the entrance-channels to the South Wales ports, with which this Paper is mainly concerned. The ordinary maintenance-costs, that is to say, repairs up to £100, account for some 25 per cent. of this figure, taking the average for the years 1933, 1934, and 1935. The cost of heavy repairs during those years averaged approximately 17 per cent. of the working costs.

Methods of Working Employed

Loading of Hoppers.

Particularly in the eastern ports, the state of fineness of the material to be dredged and the ease with which it mixes with water render it impossible to fill the hoppers to capacity with solid matter. Should this be attempted, the surplus water passes over the side heavily charged with silt. At Newport, 1 cubic yard of silt weighs about 1.2 ton and, in general, at the other ports 1.25 ton. In the entrance-channel at Swansea, where the silt also consists of wind-blown sand, the equivalent is 1.30 ton, and at Port Talbot 1.40 ton. At the two latter ports the materials dredged for extensions of deep water in dock approximated to 1.80 ton per cubic yard and comprised sand at Swansea, and gravel, boulders and clay at Port Talbot. At Swansea this represents an equivalent of 1 cubic yard of virgin sand to 1.4 cubic yard of silt.

It is the practice when hoppers are loaded with silt and water to gauge the depth of the top of the mud below the well-coamings. This is ascertained by means of a graduated gauging rod provided with a circular foot 14 inches in diameter, and readings are taken at several points. These measurements are entered in the daily log sheet, and, by reference to Tables showing the capacity obtained by previous measurement of each hopper when loaded to varying depths below the coamings, the actual cargoes carried are easily ascertained.

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Soundings.

Soundings are carried out systematically in the channels every three months, with occasional spot checks as found necessary, and, dependent upon the volume of shipping, this is also done in the docks. Wherever possible, soundings are taken by means of a steel wire 800 to 1,000 feet long with ferrules spaced 10 feet apart; fore- and back-sights are provided on shore and check-sights are taken from time to time on known shore marks, buildings, etc. The sounding chain is provided with a zinc sinker 7 inches in diameter and weighing 9½ lbs.

In the outer channels, soundings are taken as regularly as possible about every 12 feet along transits fixed by sextant readings as shore marks. Time readings are taken every 5 minutes with synchronized watches by one of the sounding-boat's crew and by a man stationed near the appropriate tide-gauge which is also read at these intervals. Copies of the sounding charts are supplied to the Chief Docks Manager for the use of his Dock Managers and Masters.

Depositing-Grounds.

The various ports are favourably situated in relation to depositing-grounds. The distances traversed by the carriers out and home when working in entrance-channels vary from three to eight miles according to the set of the tides and the positions in which the dredgers are working. At Penarth, Cardiff and Barry the maximum run does not exceed four miles. At Brentford and Chelsea the position is exceptional, as the whole of the dredged spoil has to be conveyed down the River Thames for a distance of 30½ miles before being deposited on the Essex marshes near Rainham.

Dredging-Costs.

The main factors influencing dredging-costs are:—

(a) an appropriate selection, distribution and economic use of the craft;
(b) losses of time due to weather;
(c) the exigencies of traffic.

Modernisation and Centralisation of the Great Western Railway Fleet of Dredgers

Prior to the grouping of the railways in 1922, independent dredging units were maintained by the various South Wales railway companies now incorporated in the Great Western Railway Company. The fleet, which has been modernised in recent years and, as shown in Table I, includes several powerful craft well supplied with steam hopper-barges of large carrying capacity, is now employed as one unit drawn for service at any of the Company's ports.

TABLE I—SOUTH WALES PORTS—DREDGING CRAFT IN 1936

Name and type of craft	Capacity		Dredging depths: feet		
	Dredging per hour; average cubic yards.	Carrying: cubic yards	Maximum	Minimum: normal	Minimum: abnormal
Bucket self-propelling:—					
Don Federico ...	650	—	40	19	16
David Davies ...	750	800	50	22	18
Bucket non-self-propelling:—					
Peeress	800	—	45' 11"	17	14
Foremost 49 ...	1,000	—	45 and 60	18	16
Foremost IV ...	900	—	60	18	16
Grab dredgers:—					
Mudeford	50	287	—	—	—
Francis Gilbertson ...	100	305	—	—	—
Grabber	20	—	—	—	—
Graball	128	392	—	—	—
Steam hopper barges:—					
Viscount Churchill	—	890	—	—	—
Sir Ernest Palmer	—	890	—	—	—
Sir Henry Mather Jackson	—	890	—	—	—
Foremost VI ...	—	720	—	—	—
Foremost VII ...	—	720	—	—	—
Foremost 27 ...	—	627	—	—	—
Foremost 44 ...	—	883	—	—	—
Foremost 45 ...	—	883	—	—	—
G.W.R. No. 1 ...	—	925	—	—	—
G.W.R. No. 2 ...	—	925	—	—	—

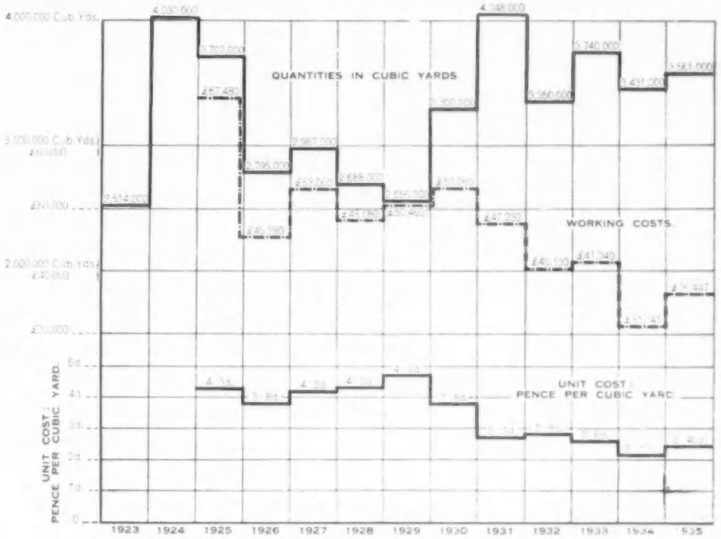

Fig. 16. Cost of Channel-Dredging and Quantities Dredged.

The tidal range in the Bristol Channel is very considerable, varying from 40.00 feet at ordinary spring tides at Newport to 26.80 feet at Swansea, with maximum recorded ranges at those ports of 45.30 feet and 32.40 feet respectively. This high range necessitates the employment of dredgers capable of dredging to considerable depths and with a wide range of ladder adjustment. Under such circumstances bucket dredgers, not capable of dredging below 45 feet, are limited in their economic usefulness.

Carriers.

An efficient hopper service is all-important, and the extended use by the Great Western Railway Company of steam hopper-barges carrying upwards of 900 cubic yards, as compared with the older types, both steam and dumb, of capacities ranging from 500 to as low as 200 cubic yards, has very materially reduced the losses of time under the headings of "changing barges" and "proceeding to and from depositing grounds."

The carrier fleet at present consists of ten steam hopper-barges of a total capacity of 8,353 cubic yards, which have replaced thirty-one craft (twelve steam and nineteen dumb) with a total capacity of 8,900 cubic yards. This fleet operates with five bucket dredgers, a reduction of four on the number previously employed.

Effective Working Time.

Records kept for many years show that the average percentage increase in actual effective dredging time, that is to say, time occupied in lifting spoil, during the last 12 years, varies from 4 per cent. at Swansea to 16 per cent. at Cardiff, where the effective time percentage in 1934 stood at 67.7 per cent. of the operating time.

A typical present-day record under the various headings under which the timing of dredging operations is divided shows that in 1933 bucket dredgers have been working 50 per cent. of the year, grab dredgers 84 per cent., and the steam hoppers 66 per cent., with a maximum for two of the barges of 88 per cent. Records are kept for each unit, showing separately for docks and channels the number of hours worked under the following headings:—starting and finishing, loading or raising, depositing and steaming, locking, traffic, weather, coaling, moorings, changing barges, awaiting barges, repairs, miscellaneous, and total. Average figures for different classes of craft are shown in Appendix I.

The periods in commission (periods during which actual loading was going on) vary from 58.6 per cent. to 66.9 per cent. of the overall time in the case of the bucket dredgers.

The following statement shows the employment of dredging craft during 1935:—

Type of vessel	Total no. of days occupied in:			Average percentage of total time:		
	Working	Repairs	Lying-up	Working	Repairs	Lying-up
Bucket dredgers	926	267	706	48·8	14·0	37·2
Grab dredgers ...	748	68	125	79·5	7·2	13·3
Steam hoppers...	1,967	319	846	62·8	10·2	27·0

Unit Costs.

The graphic diagrams (Fig. 16) show the total and the working costs of channel-dredging at the South Wales ports

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over a period of years, with actual quantities dredged. These figures are exclusive of periodical overhauls for heavy repairs and of depreciation charges.

Grab-Dredging Costs.

Dredging by grabs is carried out in ships' berths in dock, in entrance-basins, etc., and no extended use of such craft is made in channels.

Owing to the varied conditions under which these craft work, costs are very variable and would be misleading without knowledge of the particular circumstances.

Staff Arrangements.

The men employed with the Great Western Railway dredging fleet, including all units at the various ports, vary in number according to seasonal requirements from 190 to 80, of whom a nucleus is regularly employed, the remainder being engaged on a temporary basis as found necessary. The staff work under National Agreement conditions, the working hours being regulated to suit the depths of water available for dredging the tidal channels. Sleeping accommodation is provided on the new craft, the use of which is optional for the men.

APPENDIX I

ANALYSIS OF AVERAGE TIME WORKED BY DIFFERENT TYPES OF DREDGING CRAFT

Craft		Starting and finishing	Loading or raising	Depositing and steaming	Locking	Traffic	Weather	Coaling	Moorings	Changing barges	Awaiting barges	Repairs	Miscellaneous	Total
Five bucket dredgers, working in docks and channels.	Hours	44·0	835·0	32·2	12·8	59·4	32·0	5·0	175·4	92·4	29·0	25·0	14·0	1356·2
	Per cent.	3·2	61·6	2·4	0·9	4·4	2·4	0·4	12·9	6·8	2·1	1·9	1·0	100·0
Two bucket dredgers, working in channels only.	Hours	42·5	605·0	35·0	18·0	48·5	74·5	12·5	83·0	92·5	6·0	21·5	2·0	1041·0
	Per cent.	4·1	58·1	3·3	1·7	4·7	7·2	1·2	8·0	8·9	0·6	2·0	0·2	100·0
Three grab dredgers, working in docks and channels.	Hours	47·7	1435·3	528·3	137·0	92·0	44·0	36·3	132·3	4·3	0	63·7	127·3	2648·2
	Per cent.	1·8	54·2	19·9	5·2	3·5	1·6	1·4	5·0	0·2	0	2·4	4·8	100·0

		Starting and finishing	Loading and raising	Depositing and steaming	Standing by	Locking	Traffic	Weather	Coaling	Watering	Moorings	Repairs	Miscellaneous	Total
Ten steam hoppers, working in docks and channels.	Hours	35·0	531·0	662·8	208·4	68·0	48·9	38·4	9·1	4·9	121·0	8·7	18·7	1754·9
	Per cent.	2·0	30·2	37·7	11·9	3·9	2·8	2·2	0·5	0·3	6·9	0·5	1·1	100·0

Lloyd's Register Shipbuilding Returns for the Quarter ended 31st December, 1936

THE statistics issued by Lloyd's Register of Shipping regarding merchant vessels under construction at the end of December last show that in Great Britain and Ireland there is an increase of 35,071 tons in the work in hand, as compared with the figures for the previous quarter. The present total of tonnage under construction—963,642 tons—exceeds by 220,556 tons (or 30 per cent.) the tonnage which was being built at the end of December, 1935, and is the highest quarterly total recorded since September, 1930. It exceeds considerably the aggregate tonnage now under construction in the four leading countries abroad.

About 70,000 tons—7.3 per cent. of the tonnage now being built in this country—are intended for registration abroad or for sale.

The tonnage now under construction Abroad*—1,287,579 tons—is about 104,700 tons more than the work which was in hand at the end of September last.

The leading countries abroad are:—Germany, 408,465 tons; Japan, 203,146 tons; Holland, 150,850 tons; Sweden, 123,796 tons; United States of America, 110,356 tons; and Denmark, 75,950 tons.

Of the tonnage being built abroad, 413,132 tons (or 32.1 per cent.) are intended for registration elsewhere than in the Country of Build.

The total tonnage under construction in the World* amounts to 2,251,221 tons, of which 42.8 per cent. is being built in Great Britain and Ireland, and 57.2 per cent. abroad. The quarterly total for the world shows an increase of 139,784 tons over the figures at the end of September last, and is the highest recorded since December, 1930.

In Great Britain and Ireland, construction was commenced upon 272,546 tons during the last three months, a decrease of 20,630 tons, as compared with the corresponding total for the September quarter. During the quarter ended December last, 280,397 tons were launched in Great Britain and Ireland, an increase of 68,310 tons, as compared with the previous quarter. Similar figures for abroad are 468,558 tons commenced, and 404,089 tons launched, showing, as compared with the previous quarter, an increase of 74,682 tons in the tonnage commenced, and of 100,243 tons in the tonnage launched.

Steam and motor oil tankers under construction in the world amount to 80 vessels of 652,202 tons, of which 23 vessels of 179,790 tons are being built in Great Britain and Ireland, 11 vessels of 124,980 tons in Germany, 10 vessels of 79,840 tons in the United States of America, 7 of 61,766 tons in Sweden, 9 of 54,620 tons in Holland, 5 of 46,800 tons in Denmark, 6 of 29,180 tons in Japan, 3 of 22,000 tons in Italy, 3 of 20,220 tons in Spain, and 1 of 15,456 tons in France.

The vessels being built in the world at the end of December include 6 steamers and 42 motorships of between 8,000 and 10,000 tons each; 4 steamers and 22 motorships of between 10,000 and 20,000 tons; 5 steamers and 3 motorships of between 20,000 and 30,000 tons; and 2 steamers each exceeding 30,000 tons.

Of the 963,642 tons under construction in Great Britain and Ireland at the end of December, 443,736 tons consisted of motorships, while at the same date the motorship tonnage being constructed abroad (842,771 tons) was 405,963 tons in excess of that of the steamers.

The table respecting marine engines shows that the horse-power of steam engines now being built or being fitted on board amounts to about 908,000 h.p.; this figure includes 74 sets of turbine engines of about 519,000 shaft horse-power. The horse-power of the steam reciprocating engines (about 388,000 h.p.) represents 16.9 per cent. of the total horse-power of marine engines now being built in the world. The figures for oil engines aggregate approximately 1,394,000 h.p., and comprise 60.6 per cent. of the world's total horse-power of marine engines under construction.

Tonnage to Lloyd's Register Class.—Of the merchant shipbuilding in hand throughout the world at the end of December, 1,398,204 tons, or more than 62 per cent., are being built under the inspection of Lloyd's Register. Of this total, 830,237 tons, representing 86.2 per cent. of the tonnage being built there, are under construction in Great Britain and Ireland; while, of the tonnage being built abroad, 567,967 tons, or 44.1 per cent., are being constructed under the inspection of Lloyd's Register.

* Excluding Russia, for which no figures are available.

Dublin Port and Docks Board

Progress of Dublin Port in 1936

ALDERMAN A. BYRNE, Lord Mayor of Dublin, presided at a meeting of the Dublin Port and Docks Board, held on 14th January, until the Chairman, Mr. Charles M. O'Kelly, and Vice-Chairman, Capt. Gordon, were re-elected.

The Chairman (Mr. C. M. O'Kelly) reviewing the work of the year, said that there were more goods and passengers than in any previous year. The number of ships entering the port had reached the grand total of 6,071, being 237 more than in 1935.

The total net register tonnage which entered the port was 2,725,284, which constitutes a record, being 156,710 tons in excess of the previous year. In addition, 23 vessels having a total net tonnage of 231,808 anchored in the bay.

The gross receipts in 1936, were, in round figures, £219,840, and from the Custom House Docks £44,965, making a total of £264,805, an increase of £24,404 on 1935.

There would, he said be a surplus of receipts over expenditure of roughly £12,000, which must be considered satisfactory in view of the additional charge which the Board will have to meet on the issue of stock.

Referring to the fact that during the year Belfast and Dublin Harbour Boards had exchanged visits, Mr. O'Kelly said that this had done a great deal of good in the way of exchanging ideas and creating friendships.

During the year the Anchor Line submitted a scheme for the first direct passenger service between Dublin, New York, and Boston, which met with the Board's approval, and a large liner hall was constructed on Alexandra Quay, which met with the requirements of the public to a satisfactory degree. At the moment there is every prospect that the new business will expand. Shortly after these sailings were started, negotiations were opened with the Irish National Refineries, Ltd., for an extensive site for an oil refinery. Thanks to the foresight of the Board in years gone by, it was possible to offer to the Company land which had been reclaimed, and a long lease was arranged on mutually satisfactory terms.

The establishment of a trans-Atlantic passenger service, and the oil refining industry, shows that the facilities available at Dublin so impressed outsiders that they are prepared to incur considerable expenditure in connection with their works and their trade in the Port of Dublin.

In the newly-completed large tobacco warehouse in the Custom House Docks the Board has provided accommodation for the increasing trade in warehousing tobacco and other goods. There is at present warehoused 25,000 packages on which a duty alone of £10,000,000 will be payable to the State.

A State Warehouse.

With the increasing quantity of goods exported and imported at the port, it will be appreciated that the seven days' free-shed accommodation which the Board provides, has been strained to the utmost. In my opinion, this matter of congestion can only be dealt with by the provision of a State warehouse. The Board has most suitable sites for the erection of such a warehouse. The next step lies with the Customs and Excise Department.

At the North Quay extension there is approaching completion additional deep-water berthage to the extent of 800 lineal feet. Further provision is being made for shipping by extending Alexandra Quay in an easterly direction.

The Board had some commitments in connection with the oil refinery. First, to complete the area required, the Board are at present enclosing a further 17 acres of foreshore, which will shortly be reclaimed, and be included within the refinery site, making in all, 70 acres. Alongside this new area the Board has undertaken to carry out a large scheme of dredging, to give access to the two wharves which the Board is constructing for the Company, and at which the largest oil tankers can lie afloat at all stages of the tide.

In connection with the oil refineries, two companies have been registered with a capital of £1,000,000 each, and named Irish National Refineries, Ltd., and Liffey Transport and Trading, Ltd. It is understood that the entire share capital of each company will be issued this year. In addition, it is understood that there will be a debenture issue of £1,000,000 made by each company. An order for seven large oil tankers has been placed, and plans for the construction of the refinery are nearing completion.

These works, together with the progress of the East Wall reclamation represent the Board's scheme of improvements at present contemplated. They involved a considerable capital outlay, for which the necessary financial arrangements have been made.

In order to raise funds to meet capital outlay, the Board, in the early part of 1936, made an issue of £150,000 4 per cent. Dublin Port and Docks Board Redeemable Stock (1975-1995), and last month, in connection with the foregoing works, made a further issue of £100,000 of this stock, both issues being considerably over-subscribed, which is evidence of the continued confidence of the public in the Board's undertaking.

While it is important that the Board should adopt a progressive policy of improvements, the adequate maintenance of the port is of equal, if not greater, importance.

Owing to the deposit of mud and silt brought down by floods in the Liffey to the navigable channel and berths, the navigable depth over the Bar at the entrance to the port has had to be maintained by dredging. This has not been neglected. During the year two and a half million tons of mud and silt were removed, a record dredging for any one year.

Despite the heavy charges for maintenance, the Port of Dublin is a cheap port, and this is a position which it will be the work of the Board to uphold, but there is an apprehension amongst those connected with shipping that that good name may be jeopardised by the demands of labour for the work of loading and unloading ships. All the plant and equipment of the port, he said, was in good working condition, and the best possible service would be given to all ships entering the port.

Dublin Port Board Secretary.

At the end of March next, Mr. Edward H. Bailey, 11, Holmpatrick Terrace, Skerries, Co. Dublin, will resign from his post as Secretary to the Dublin Port and Docks Board. He entered the service of the Board on the 17th May, 1884, so that when his retirement takes effect he will have completed nearly 53 years' service. He first took up duty in the Custom House Docks Department under the late Mr. F. C. Simpson. Later, he was transferred to the accounts department in the Ballast Office, Westmoreland Street, and in 1913 he was made accountant, to which were added the duties of Collector of Port Dues in 1919. Finally, in 1921, he was appointed Secretary, and took charge of the entire office at Westmoreland Street, in succession to the late Mr. Nicholas Proud.

Port of London's Record Year

Shipping Record.

During 1936—62,168,833 net registered tons of shipping used the Port of London, compared with 59,762,150 net registered tons during 1935. This constitutes a record for all time, and is an increase of 4 per cent. over the previous record reached in 1935.

A noteworthy feature of London's shipping last year was the large number of newly-constructed vessels put into commission for employment between London and various parts of the world and the British coasting trade. Altogether, some 40 new freight and passenger liners were added to the port's regular shipping services. In addition, to feed the steadily increasing output of electricity on Thameside, the already large fleet of colliers regularly serving the port was augmented by a number of new vessels in this category.

Cargoes.

Complete figures for the tonnage of goods dealt with in the port during the same period are not yet available, but returns so far to hand indicate a substantial increase in the port's trade.

Passenger Traffic.

There was an increase in the number of vessels that used the Tilbury Passenger Landing Stage, together with the number of passengers embarked and disembarked. The number of ships accommodated was 704, representing 6,419,507 tons gross.

Passenger traffic is also dealt with, of course, in the docks and at some of the riverside wharves, and the aggregate figures for the year are expected to disclose a substantial increase.

London's Pre-eminence.

The Board of Trade's preliminary figures for shipping that used the principal ports of the United Kingdom during 1936 are as under, viz. :—

	Net Reg. Tons
London	62,168,833
Liverpool	34,304,609
Southampton	25,712,142
Hull	11,902,421
Manchester	7,775,720
Bristol	7,321,802

Aden Port Trust

The following are the returns of shipping using the Port of Aden for the month of November, 1936:—

	No.	Tonnage
Merchant Vessels over 200 tons ...	154	621,840
,, ,, under 200 tons ...	1	162
Government Vessels	6	31,946
Dhows	117	5,770
PERIM.		
Merchant Vessels over 200 tons ...	—	—

The total value of imports, excluding Government Stores, was Rs. 57,14,000/-, as compared with Rs. 69,54,000/- for November, 1935, and of exports Rs. 37,83,000/-, as compared with Rs. 45,26,000/-. The corresponding figures for 1934 were Rs. 46,03,000/- and Rs. 29,72,000/-.

The total value of both imports and exports together was Rs. 94,97,000/-, as compared with Rs. 114,80,000/- for the corresponding month last year, and Rs. 75,75,000/- for 1934.

Imports during the month were above those for November, 1935, in the case of raw hides, sugar, manufactured tobacco, and private treasure; and below, in the case of coffee, grain, pulse and flour, gums and resins, hardware, seeds, raw skins, grey, white and printed or dyed piece-goods, twist and yarn, and unmanufactured tobacco.

Exports were above those for November, 1935, in the case of raw hides, white piece-goods, manufactured and unmanufactured tobacco; and below, in the case of coffee, grain, pulse and flour, gums and resins, hardware, seeds, raw skins, sugar, grey and printed or dyed piece-goods, twist and yarn, and private treasure.

TRADE OF THE PORT.

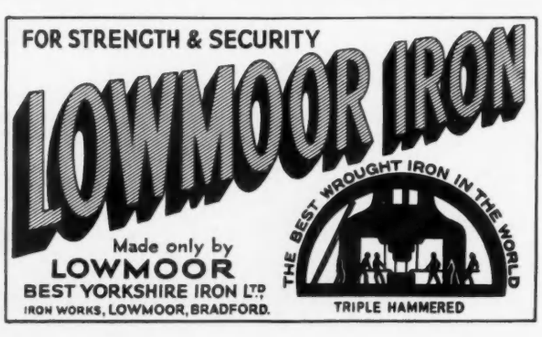
Article.	Unit	Imports		Exports	
		Quantity.	Value Rs.	Quantity.	Value Rs.
Coal	Tons	3,787	75,740	0	0
Coffee	Cwts.	3,891	89,324	8,379	2,79,339
Grain, Pulse and Flour	,,	56,312	3,24,461	56,330	3,06,509
Gums and Resins	,,	1,664	29,282	2,537	55,279
Hardware	—	0	31,921	0	31,364
Hides, raw	No.	7,822	7,618	9,801	19,542
Oil, Fuel	Tons	53,978	12,68,755	4,950	1,07,327
,, Kerosene	Gls.	26,840	17,639	1,492	943
,, Petrol	,,	36,827	35,076	1,632	3,052
Salt	Tons	0	0	33,551	3,26,220
Seeds	Cwts.	2,532	23,300	838	7,234
Skins, raw	No.	334,249	2,81,771	465,598	6,25,026
Sugar	Cwts.	76,748	3,64,944	16,530	75,930
Textiles—					
Piece Goods, Grey	Yds.	2,624,839	3,25,300	3,109,210	3,84,174
,, ,, White	,,	722,129	1,20,524	595,497	95,795
,, ,, Printed or Dyed	,,	1,508,357	2,88,900	2,004,037	4,34,581
Twist and Yarn	Lbs.	171,960	73,190	100,140	42,153
Tobacco, Unmanufactured	,,	237,440	37,058	499,156	85,777
,, Manufactured	,,	81,508	78,526	48,916	47,954
Other Articles	No. of Pkges.	124,931	18,35,508	55,538	6,89,529
Treasure, Private	—	0	4,04,970	0	1,64,980
Total ...	—	—	57,13,807	—	37,82,708

The number of merchant vessels over 200 tons that used the port in November, 1936, was 154, compared with 139 in the corresponding month last year, and 141 in 1934, and the total tonnage was 622,000, as compared with 593,000 in 1935, and 605,000 in 1934.

Excluding coal, salt, fuel oil and Military and Naval Stores and transhipment cargo, the total tonnage of imports in the month was 16,200 and of exports 9,400, as compared with 17,200 and 8,800 respectively for the corresponding month last year, and 8,500 and 6,300 for 1934.

British Columbia's Import Trade

The annual summary issued by the Industrial Department of the Vancouver Board of Trade covering the major commodity imports into the four western provinces of the Dominion has lately been issued. The imports are divided into nine groups, and attention is drawn to the fact that the total increase of $10,293,000 recorded for the year is divided between lines that must be imported in view of the fact that they are not produced in Western Canada, and lines that might be. In the latter category are sauces, catsup, wheat flour, confectionery and candy, boots and shoes, cheese, worsteds and serges, blankets, plywood, furniture, converted paper products, zinc sheets, zinc dust, Diesel engines, gasoline, lubricating and other oils, shoe-blacking, toys, and fishing tackle. In this connection, it may be mentioned that the Industrial Department of the Vancouver Board of Trade has an Industrial Committee which is always ready to advise prospective industrialists who may be considering the manufacture of commodities non-competitive with those already made in the area.



Canned Salmon.

The British Columbia canned salmon pack, as at November 28th, was larger by over 300,000 cases than for the same period a year ago, and very nearly three times as large as it was in 1931. The figures for the last five years are:—

	Cases
1936	1,851,533
1935	1,529,022
1934	1,582,926
1933	1,265,072
1932	1,081,031

The figures for dry salt herring production for the same period are:—

	Tons
1936	18,255
1935	12,056
1934	18,182
1933	21,733
1932	11,091